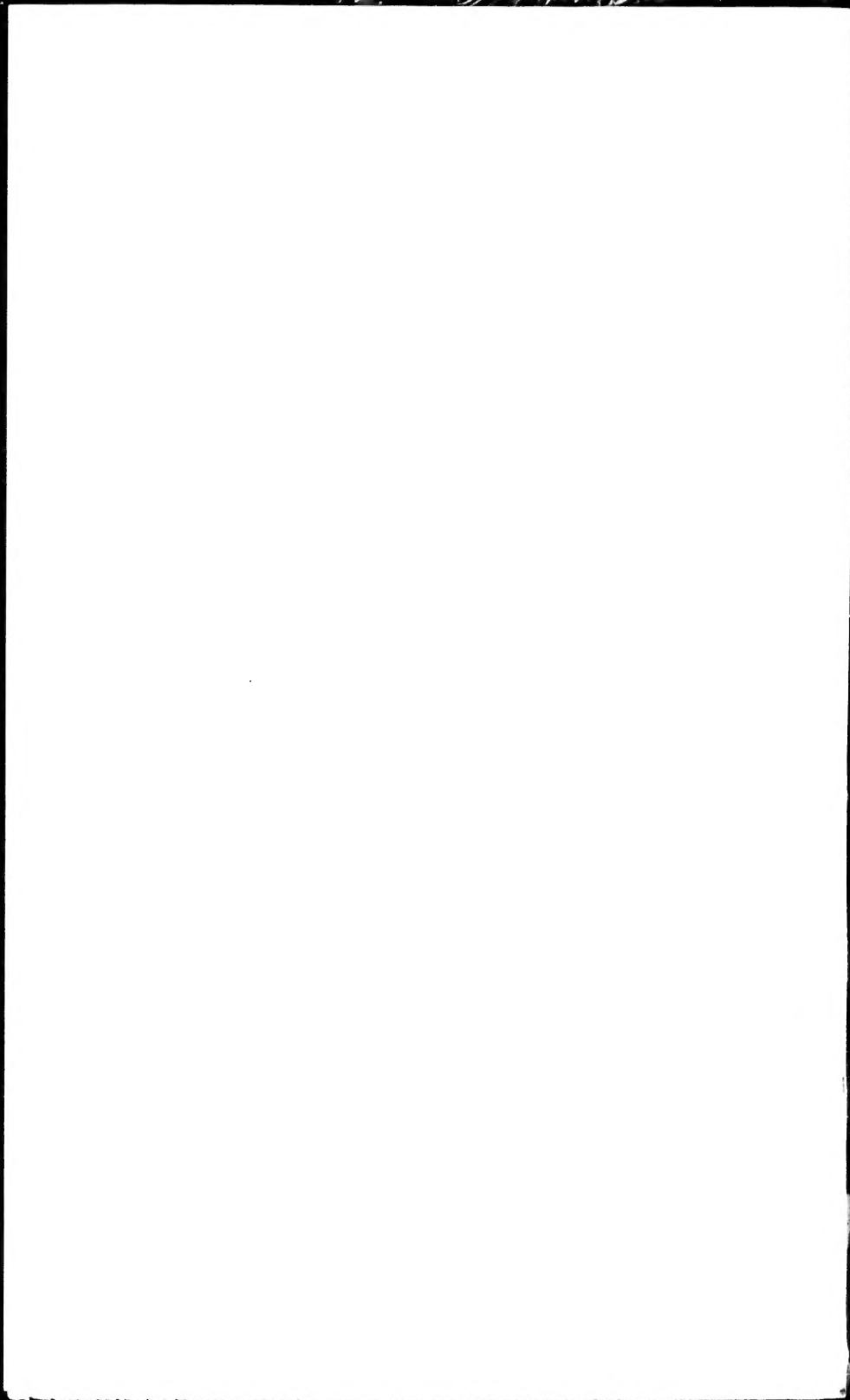
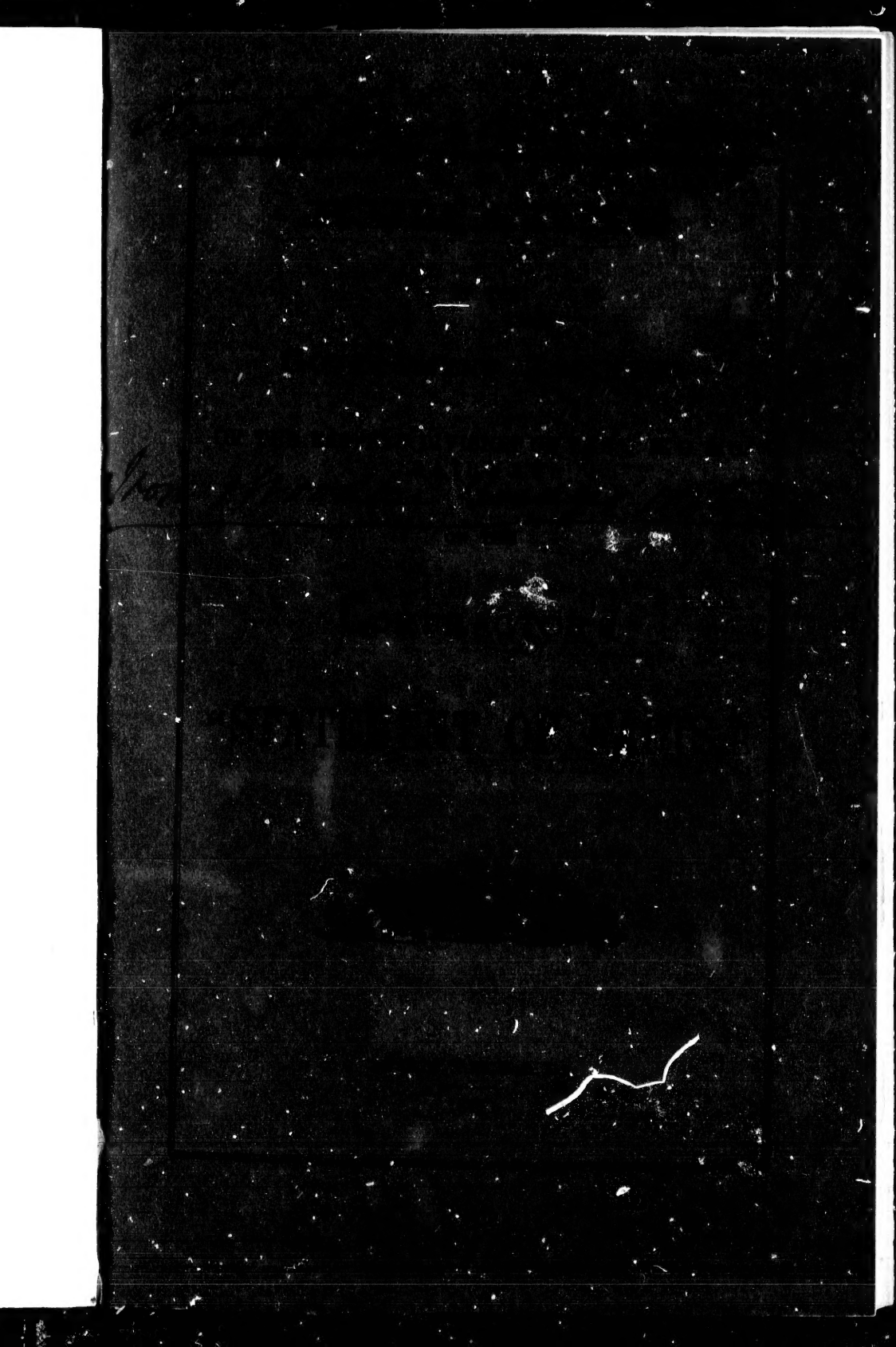






REMARKS

BY THE

GOVERNMENT ENGINEER

OF THE EASTERN DIVISION OF THE Q. M. O. & O.
RAILWAY,

ON THE

CONTRACTOR'S

"STATEMENT OF FACTS."



MONTREAL:

1877.

10

*To the Commissioners of the Q. M.
O. & O. Railway.*

GENTLEMEN,

A pamphlet, intended to create the impression that the Contractor for the Eastern Division of the Q. M. O. & O. Railway has reasonable grounds of complaint against both you and myself, having been recently addressed by him to the Premier of this Province, I have the honor to offer the following remarks thereon, merely premising that I have contented myself with meeting as briefly as possible each assertion of a pretended grievance in the order it has been made, without noticing what is undeserving of serious attention, in this cunningly, if some what unscrupulously, devised jeremiade.

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REMARKS

ON THE

Contractor's "Statement of Facts."

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ENGINEERING AND INSPECTION.

1. The contractor states: "All engineers, except as provided for in clause 2, are appointed and paid by me, and under my control; carrying this out, I organized the necessary staff, under my engineer, to make plans. Notwithstanding, the Commissioners have a staff making plans, &c., at the Chief Engineer's office."

REMARKS.—The only engineers appointed by the contractor, outside of his own official staff, are the assistants.

They are subject to the approval of the Commissioners and the dismissal of the Chief Engineer. A staff was required from the first, as such plans as were submitted by the contractor had to be modified or completely changed, while many others like those for the St. Maurice Bridge, had to be designed throughout in the Government Engineer's office.

2. The contractor complains: "The Commissioners have removed from the late Railway Company Engineer's office, all the furniture, tools and implements belonging to me to their own office, and to carry out clause 1 of the contract, I was obliged to furnish others."

REMARKS.—This was done by order of the Commissioners.

3. The contractor states: "In June last, I organized a staff and sent them out to complete location in accordance with contract. The Commissioners compelled me to disband them, saying they had full control of that department, &c."

REMARKS.—I am not aware of any clause which gives the contractor control of the location; all locations are very properly made by the Government under their own engineers.

4. The contractor says: "The number of inspectors on this road is far beyond anything that is necessary or usually employed on other roads. During the past season, in the distance of 102 miles, there were 15 inspectors and 2 general inspectors, the two latter and ten of the fifteen were on masonry extending over 80 miles; this makes one inspector to every $5\frac{1}{2}$ miles, whereas the Inter-colonial averaged one masonry inspector to every 20 miles. The latter road gave an inspector a district, and all structures within that limit he was obliged to attend to; on

"the road under contract by me, there was no system, mostly every structure having a separate inspector, no matter how close to each other. I have seen inspectors within sight of each other; in some cases there were four inspectors who would meet at one structure."

REMARKS.—Two inspectors were employed on every 25 miles on the Intercolonial Railway, and one inspector was always retained in winter to inspect quarrying and dressing of stone. On reference to the letter of Mr. Lindsay (Appendix 1) it will be found that on the present work one inspector was employed for every eleven miles; but as the duties of one of the inspectors was confined to St. Anne's Bridge, which absorbed his whole attention, the supervision of the line was in reality exercised by the four inspectors, who had nothing to do with this bridge. Less than this number would not have sufficed. Inspectors would of course be in sight of each other when they met at the end of their sections. If four inspectors ever did meet at one structure, it must have been purely accidental. It moreover became imperative to maintain a rigid inspection, owing to the continual disposition shewn by Mr. Robert McGreevy, the contractor's brother and agent, to thwart the Government inspectors. Both engineers and inspectors report him in the habit of covertly countermanding their orders to the sub-contractors, and inciting the latter to do work inferior to specification.

5. The contractor appends a comparative statement marked A, of cost per mile on the I. C. R. in 1873, and on this road in 1876, shewing an excess of cost of supervision on this road.

REMARKS.—On the I. C. R., the division engineers had the same pay as they have on this road. They had charge, there of 25 miles, here of 50 miles. There was there an assistant to every $12\frac{1}{2}$ miles, with a yearly salary of \$1,200.

Here the assistants have charge of 19 miles, with \$75 per month, and are discharged through the winter, making half time. Two inspectors on the I. C. R. were paid \$100 per month ; one continuously, the other half-time. Here, they are paid \$75 per month, and are only employed during the working season. One of the main causes tending to swell the cost of inspectors is, not their number, but the very slow way in which the works are carried on, owing to the inadequate prices paid to sub-contractors, and constant detentions during the past season for want of stone. No matter at what rate the work progresses, inspectors have to be retained.

6. The contractor says : " Messrs. Boyd and Sutherland, two general inspectors, at large salaries, have been put over the other inspectors. This was never done on the I. C. R., but the division engineer was to supervise the inspectors. This gave rise to several different orders, and as many classes of work ; in many cases the local inspector and division engineer's order was set aside, as well as the contract or specification."

REMARKS.—Most of this statement is contrary to fact. The want of uniformity caused by Mr. R. McGreevy's disposition to do inferior work, and the fact that some of the sub-contractors were doing much better work than others, made the appointment of a principal inspecting engineer necessary, which position Mr. Boyd now ably fills. He flatly denies the charges of changing specifications or giving different orders, classes of works, &c. Mr. Sutherland was appointed inspector *pro tem.*, at a monthly salary of \$75, the work of the section being too much for Mr. Trépanier.

Reference is here specially requested to Appendices 1 and 2, where this subject is fully discussed.

7. The contractor says: "No allusion is made in the above to parties on the survey between Maskinongé and Montreal."

REMARK.—As these parties were employed by the Commissioners, and entirely out of the contractor's jurisdiction, no further reference need be made to them.

8. The contractor says: "I wrote on the 3rd November, notifying them to disband all staff on the work; nevertheless, all the engineers and some of the inspectors are still under pay, though having nothing to do."

REMARKS.—The inspectors were all discharged, save one to look after the quarries, as soon as work ceased on their sections. The assistants had to be retained a short time to plot their cross-sections, notes, &c., without which their summer's work would have been unintelligible; afterwards, they too were discharged.

EARTH EXCAVATION, (GRADING.)

1. The contractor states: "The contract schedule provided for 2,014,200 yards, for the entire line; this includes the 500,000 additional, called for by Messrs. Baillairgé & Light's report, see page 49 of printed pamphlet, as forming part of the present contract."

REMARKS.—The quantities are here correctly quoted. I am not responsible for them. They, as well as the profiles from which they were deduced, were arranged by my predecessors. The profiles form an important part of the contract, and govern the quantity of grading, be it more or less.

2. The contractor says: "Immediately, upon opening work last spring, the grades were raised considerably over what was required by the contract amended profiles, referred to in report above alluded to; in

"many cases fully five feet. Fearing this would lead to more than a reasonable addition, and would entail other works, I refused to proceed without a proper order."

REMARKS.—The changes in question were very necessary and were those approved by the Government, viz: a raise of grade at a few points between Quebec and Three Rivers, to get the rail level above ground, involving 118,000 cubic yards earth, and 310 yards of masonry; also, a change of line near Portneuf, involving 22,000 yards more. A general raise will also have to be made, for several miles east of Berthier, where the original grades had been laid some five feet below flood level, causing an unexpected increase of 77,000 yards, or a total of 217,000 yards. The latter change has not yet been approved.

3 The contractor states: "In September when a greater part of located line was under construction, and nearly completed, this side of Portneuf river, the work was stopped for a change of line required by your chief, for a distance of about a mile. Most of the season was lost before a decision was come to, and even at the last moment the proper order was not issued, nor yet, tho' promised by your engineer. This has compelled this work to be done in winter at a very large cost, deep clay cuttings which should have been done in summer. This has delayed other works both sides of the change."

REMARKS.—This change I have already referred to. It was a most necessary one. It got rid of a 6 degree curve, and 34 degrees of curvature on a long maximum grade, which would have greatly crippled the line, no other curves exceeding 4 degrees. The change was recommended as soon as a survey could be made shewing its feasibility. The orders to make the changes are given by the Governor in Council. The change did not interfere with other works on either side, and as operations on this part of the line

ceased before the close of the year, it could not have caused a great excess of cost for winter work, there being only 10,000 yards taken out, to the present time, in the clay cuttings referred to. To finish the entire grading in accordance with the last amended profiles, will take about 300,000 yards in addition to schedule quantities, or 50,000 yards more than stated in a foot note to Messrs. Baillaigé and Light's report of 13th March, 1875. (See Appendix 4). This excess is made up of the above rectifications, and a balance of 83,000, instead of 1,000,000, as the contractor states.

FOUNDATIONS.

1. The contractor states: "The schedule based on the specification attached to contract, provides for \$118,000, for the entire work of foundations on the whole line. The classes of foundation the chief engineer has exacted where artificial works were necessary, and which were operated upon last season, and those proposed to be done as per plans now before me, will entail an expenditure of \$350,000, or an excess of \$232,000, over what is already provided. When this present contract was made, it was based on and included all the plans, specifications and conditions of previous contracts then in existence, (see last paragraph of preamble, page 5 of printed contract), with the various additions as contained in the circulars, &c., alluded to in same paragraph. All the plans and specifications, (see page 53, of printed contract) for artificial foundations were approved of by the railway company, before signing the present contract, and as Messrs. Baillaigé and Light, to whom was referred the whole matter of class of road, did not object to the plans and specifications then adopted by the company, but recommended alteration and strengthening of some (see clause 6 of Baillaigé and Light's report, page 51, printed contract), before the plans above referred to were made, the borings to as-

"certain nature and depth of soil at Batiscan, St. Maurice, St. Anne, and Bout de l'Île were made under the then engineer, and in some cases a second boring was taken of the foundations; all this, together with the fact that some of the foundations were already done, fixed them to be as per plans and specifications then forming part of contract, with the addition as provided in report, and the sum of money required for this service, monied out for each item, Schedule B."

REMARKS.—It is true the present contract was based on the specifications and conditions of previous existing contracts, but the plans were specially ignored; I always pronounced them to be deficient, and the quantities deduced from them "too small;" but I am not responsible for them, as they were arranged before I took charge of the work. The structures built on them were condemned in my report to the Government, of 12th January, 1875, and also in the joint report of Messrs. Baillairgé and Light, of the 13th March, 1875, embodied in the contract, (see Appendices Nos. 3 and 4). A special clause in the latter stipulates that the contractor binds himself to make all changes in plans, &c., (see Appendix 5). I knew the foundations would have to be enlarged, and clause 1, above mentioned, was meant to cover them. It is quite possible that these enlargements are much more extensive than the contractor contemplated, but they are just what they should be. The value of these foundations, as nearly as can now be arrived at, is \$268,000, or an excess of \$150,000 over schedule quantities. The additions are merely sufficient to make the works safe and permanent, a more important consideration than that of expenditure.

2. The contractor says: "In the beginning of March, I submitted to the Government Engineer, plan of Batiscan river foundation to meet the requirements of the sixth paragraph of the report above alluded to. This plan was

"not approved. To meet the Government Engineer's views, new plans were made and duly signed and approved by him on the 11th March. Work was commenced, and some of the foundations completed."

REMARK.—Only one of the foundations was partially completed before a change was ordered.

3. The contractor says: "On the 2nd August, your engineer forbid our proceeding with these foundations until the piles had been tested by placing an enormous weight upon some of them. This was complied with, and on 4th were ready for inspection."

REMARK.—The "enormous weight" here spoken of was simply the proportion each pile would have to bear, viz: the weight of the pier itself, the iron superstructure, and the rolling-load, with a small allowance for vibration.

4. The contractor says: "On the 29th August, your engineer stopped the work by insisting on another plan (see Appendix G); the work already done and approved of was taken up, and the plan refused in March, substituted, thereby virtually causing the loss of the season and a large sum of money by delay, damages and work not paid for in the changes."

REMARKS.—The only change that has been made in the plans of this bridge, is in the foundations, and on only one of these was any work done over a second time; viz:—Pulling up one tier of the floor in pier No. 1, a comparatively trifling matter, the timber being all used again. The change was mainly necessitated by the fallacious character of the borings taken before the works came under my charge; the absence of correct data had prevented me from studying the subject, as it should have been, in advance. The borings taken shewed a hard bottom fifteen feet beneath the river bed. When the works were

commenced, it was found that no such hard bottom existed. Piles were driven three times this depth into soft material, and as the bearing piles that had been delivered for the foundations, were only in twenty-five feet lengths, in order to utilise them and meet the difficulty the bases of the piers were enlarged. When the foundations were finally pumped out, the bottom was found so treacherous that three feet of concrete had to be put under the floor to stiffen it, and ensure safety. The contractor's statement that the plan "refused in March" was afterwards "substituted" can be disproved by the following comparison of the foundations of one pier :

CONTRACTOR'S PLAN SUBMITTED IN MARCH, 1876.	PLAN ADOPTED.
Number of rows of piles..... 4	Number of rows of piles..... 8
Width of platform..... 13 ft.	Width of platform 24 ft.
Number of tiers cross-timbers..... 1	Number of tiers cross-timbers..... 2
Lumber in floor, cube feet..... 595	Lumber in floor, cube feet..... 2000
Thickness of concrete in feet..... 2	Thickness of concrete in feet..... 3
Cube yards of concrete..... 26	Cube yards of concrete..... 100

The additional tier of timber was cheaper than masonry, and helped to distribute the superincumbent weight of the narrow pier over the wide floor. Nothing was done but what was necessary to ensure stability, and the foundation is the cheapest that could be safely devised for the situation. From the soft nature of the River bed, there can be no doubt that if the foundation had been put in on the plan first submitted, it would have sunk bodily under the weight of the high piers. The real causes of delay were : first, the fact that about half enough stone was delivered to complete the masonry during the past working season ; the other half having been delivered last winter. Secondly, the

fact of the two western piers having been misplaced by the Contractor's Engineer, by which two rows of piles in each pier were mis-driven. (See Flanagan's letter in Contractor's Appendix J J J and Appendix 42); and thirdly, a marked insufficiency of plant to carry on the piers simultaneously.

ST. ANNE'S BRIDGE.

1. The contractor states: "Foundations St. Anne's, were " in position in 1875, as required by plans and specifications " (See Appendix I and J.) When about to commence the " masonry on the West abutment of East or main channel, " it was stopped, until a new platform was put on. Pier " 1, had to be surrounded by a cofferdam pumped out, the " old foundations changed, preventing the masonry of this " pier being completed last season (Appendix K. and L.) " Draw pier which in contemplation to do away with. No " decision yet."

REMARKS.—The foundation in position in 1875, was on a T. form, and the abutment proposed to be built on it differed materially from the Eastern abutment, already half built. The plan had several objectionable features, and had been specially condemned by me. (Appendix 6). It will be seen by (Appendices 7 and 8), that the contractor did his utmost to carry it out in direct violation of his contract. It was only by the Commissioners taking strong ground, that he was prevented from so doing, and at length compelled to build the bridge on an approved plan.

Clause 1, (Appendix 5,) of the contract distinctly binds the contractor "to make all changes in plans," &c., and provides that "all plans shall be approved by the Government Engineer before the works are begun." The foundation of pier 1, was faulty, being "stilted up," on a pile

foundation, previously condemned by me, (see my report of 12th January, 1875, and Messrs. Baillairgé and Light's report of 18th March, 1875, (in Appendices 3 and 4). The contractor was notified to cut this pier down to the level of the river bottom, early in the season, but he persistently evaded the order, and only complied with it near the close of the season; still in time enough however, to have completed the pier, had there been stone on the ground. I have strongly objected to the "draw" in this bridge, and have endeavoured to have it done away with, but the decision does not rest with me.

2. The contractor states: "All these delays prevented this Bridge being completed last season. Regarding delays, damages, and work not paid for, this bridge is the same as Batiscan."

REMARKS.—The contractor is directly responsible for all delays on the works, except as regards the draw-bridge at St. Anne's. With this single exception all delays have been caused by mismanagement, a deficiency of stone and plant to carry on the piers simultaneously, and by the contractor's persistent efforts to evade the plain terms of his contract.

ST. MAURICE BRIDGE.

1. The contractor says; "on the 8th May, I wrote to the Government Engineer, (See Appendix M.) sending two plans of foundations and piers for this river (St. Maurice), on a very solid and approved system."

REMARKS.—Both the plans of foundations in question, were of a very temporary and unsafe description, being mere cribs of timber, some twenty-five feet high, founded on piles; the crib extending from the river bottom to within five feet of low water. The faces composed of a single thickness of 12" x 12" timber, laid three inches open, the spaces furred up with deals, and the interior filled with

loose stone. I pointed out to the contractor, that the great run of logs peculiar to this river, would rapidly wear away the unprotected corners of the cribs, and the piers extending fifty feet above them would be destroyed. This opinion was fully endorsed by the Board, and the plans condemned on the 21st May.

2. The contractor says: "On 14th February, your engineer sent letter regarding boring which referred almost entirely to Portneuf; but as all this had already been previously done before plans were made, and as he exacted a class of tools not in Canada, without complying with clause 16, of contract regarding extras, I did not feel called upon to notice it. In the same letter he suggests a class of foundations, similar to the one I sent him in May, and since rejected."

REMARKS.—My letter to the contractor of 14th February, especially referred to the St. Maurice, as I considered that river more important than Portneuf, (Appendix 9.) So called borings had been taken, with unsuitable implements, but I told the contractor they would only mislead him; especially, as they had not been taken at the bridge site, but one hundred feet further down the stream, the line having been moved since they were taken, (see Appendix 10.) I therefore strongly urged upon him, the necessity of having proper borings made, before he committed himself to any plan, (see letter, Appendix 9.) I did not "exact a class of tools not in Canada," but I informed him where two sets, such as I recommended, could be had—failing this, I told him that they could be made at any machine shop in the Dominion, under competent directions. It is the contractor's business to have proper borings taken, therefore they cannot be considered as an "extra." The foundation I recommended in my letter, differed entirely from that submitted by the contractor in May. Instead of a mere crib filled with loose stone, the masonry was

to be sunk in a caisson, founded on piles sawn off at the river bottom. By way of utilising the timber delivered for the condemned foundation of the Company, I told the contractor that I would not object to the *caisson bottom* being composed of several thicknesses of square timber, laid close and alternately and thoroughly bolted into a solid block, the whole to be buried in rip-rap. Such a foundation is safe and enduring, and is precisely what is now being built. (See Appendices.)

3. The contractor states: "On 9th August, my engineer wrote your engineer for a decision."

REMARKS.—I at once notified the Division Engineer that the contractor might put in a coffer-dam at pier 4. He replied that they objected to begin the dam, as there was no stone to build the masonry, and the dam would probably be destroyed by ice in winter, (see letter Appendix 11.)

4. The contractor states: "No official decision on plans submitted, until 18th Dec., 1876, when a programme of foundations was sent by your chief engineer, the cost of which will almost come up to the whole sum provided for in contract, intended to cover *all* foundations on the line."

REMARKS.—I have already stated that the "plans submitted," were at once condemned. As I returned them myself, to the contractor's engineer, on the 23rd May, 1876, I certainly did not think it was necessary to send an official letter. The contractor has taken advantage of this circumstance to profess ignorance of my decision. The "programme of foundations," complained of, is what I had recommended on the 14th February, 1876, just ten months previous to the date above mentioned, by the contractor. As to its "cost," it is the cheapest possible way in which the

work could be done, with any regard to safety, and permanence. On the 4th September, 1876, I received the complete borings of the St. Maurice, without which I had told the contractor, I would not consider any plans. On the 16th of same month, I informed him, at a full meeting of the Board, that I would discuss the question. He replied "there is no hurry, there is no stone, and I wish to make a winter's job of it." Not approving of this delay, I prepared and submitted a set of plans similar to those I had recommended, on the 14th February. The contractor meantime having declared his inability to prepare satisfactory plans, the Board directed me to send them to him which I did, at the end of December, (see correspondence in Appendix 12.)

5. The contractor says: "About a month ago, I submitted in an informal manner plans of iron cylinders, approved of by the most eminent engineers in Canada. This plan was rejected by your chief engineer in a few hours after its being in his possession."

REMARKS.—It certainly did not take me much time to judge of the utter unsuitableness of the plan in question. It consisted of iron cylinders 8 feet in diameter, $\frac{1}{2}$ an inch thick, set in pairs at each pier. They were placed 7 feet apart, set 3 feet into the clay bed of the river, with piles driven into the river bottom, from the inside of the cylinder, which was filled with concrete. There was no connection below the water, which was here some 30 feet deep, at low water with a rapid current. I have no hesitation in saying that the contraction and expansion of the ice above would speedily have destroyed them, not to mention the immense pressure from logs, to which they would yearly be subjected. The "eminent" Canadian engineers referred to have certainly never had the hardihood to try them in their own country. They work well in tropical climates. I used them successfully in my practice in South America.

In Russia they signally failed. The remarks as to the causes of delay at Batiscan and St. Anne's Bridges, apply to the St. Maurice, but with still more force. The sincerity of the contractor's desire to proceed vigorously, with the works, so much affected in his correspondence, and that of his employées, will be best tested by the following facts; 1st that up to the 1st December, 1876, not a single dimension stone, for the St. Maurice Bridge, was on the ground, and only 58 out of 400 bearing-piles required for the foundations of the two central piers, had been delivered; and secondly, on No. 2 district, 50 miles in length, which includes Batiscan and St. Maurice Bridges, and other large structures, containing 16,588 yards of masonry yet to build, up to 11th Dec., 1876, there were but 258 yards of dressed stone delivered, not one yard of which was delivered at St. Maurice, (see letters of Messrs. Hamlin & Boyd, in Appendix 13.)

PORTNEUF.

1st. The contractor says: "Both pier foundations of this structure (Portneuf bridge) were in, and masonry built about twelve feet high under the late North Shore Railway Company, from plans made by their engineer; these were approved of by your engineer, (see 5th paragraph of report, page 51, printed contract.) The abutments were placed in their position on the same plan."

REMARKS.—It is true that the bases of the two piers were in place and carried up about ten feet when I was appointed Government Engineer in September, 1875. I subsequently made a critical examination of the work, and found the masonry at the Eastern pier especially, exceedingly bad, in no single respect up to specification, and quite unfit for this important structure, (see letters on this subject, Appendix 14.) The plans were never approved by me. In the report above quoted by the contractor, my remarks referred to the "batter" and "size" of the mason-

ry; not to its character, or to the foundation. The situation of the Bridge is a peculiarly dangerous one. It spans a gorge some sixty feet deep, the rail level being upwards of seventy feet above the water. The sides of the ravine are composed of slippery blue clay, and are liable to heavy land-slides; and the foundations on the Eastern side, specially demanded very careful consideration.

2nd. The contractor states: (in a letter dated 14th Feby., 1876:) "Your engineer calls for borings to be made on a scale but with tools not in this country, but for reasons already stated I took no notice of the letter in as much as the necessary order required by clause sixteen was not complied with, which should have been done, as this structure was one of those already approved of."

REMARKS.—I apply to this statement the remarks I have already made on the same subject as regards St. Maurice, viz: The tools were to be had in this country; in in any case they could have been specially made; no "order" was "necessary." Clause sixteen only treats of "extras," and borings do not come under that head.

3. The contractor says: "On 21st April, I submitted plans of this bridge, based on the previous one, with the addition of deeper abutment foundations and borings taken with such tools as the country afforded. No decision was come to for some time, as both Commission and Chief Engineer were endeavoring to obtain iron superstructures instead of wood, as provided by the contract, in addition to which the Chief Engineer had an idea of iron trestle viaducts."

REMARKS.—I accepted the general plan of the abutments; *i. e.* the masonry, not the foundations. No borings at all had been taken, the ground having been merely sounded with a bar. I had to withhold my decision about

the piers, as the question of iron or wooden superstructures was in abeyance. An iron trestle viaduct had been considered, but never at all recommended by me.

4. The contractor says: "On the 31st May, my engineer " having been informed that it was decided to conform to " the original spanning with wooden trusses, wrote your " engineer asking leave to proceed with the masonry. It " was about the same time a new idea arose of taking down " the two piers, for the reason that the foundation was " questionable, and to equalise the spanning of the river ; " this led to a long controversy, the result of which was to " save time, I submitted to; took down the East one, and " rebuilt it in same spot, and on the same platform. This " caused a delay of some two months or more to the work."

REMARKS.—On receipt of the letter above mentioned, I at once notified the Board that I most certainly considered the foundation "questionable," and that I entirely disapproved of the masonry; I therefore advised that the small amount of work completed on the piers should be taken down, which was accordingly done on the East pier. (See letters in Appendix 14.) Proper borings, which the contractor had hitherto persistently refused, were then made on the site of the removed pier, and as these disclosed the satisfactory nature of the ground, the pier was rebuilt on its former site. I certainly would not consent to the work going on, until this fact was clearly established; the masonry in the East pier being utterly unfit for so important a structure would have had to come down in any case. The spans at present are unequal. Had new iron superstructures been put in, it was intended to equalise them, but as the Board decided to retain the wooden trusses which had been already framed to fit the unequal spans, the pier was of course rebuilt "in the same spot," but now with good masonry. The contractor may thank himself for the "two months delay." Two-thirds of the season had been

wasted, owing to the want of stone, and his refusal to make proper borings. I know of no other causes. The removal of the base of the pier mentioned, containing some 100 yards of masonry, occupied about two or three days.

5 The contractor says: "I have the opinion of the best engineering skill in Canada, which will be shewn you if necessary, who are of opinion that the piling to East abutment exacted by the Chief Engineer, was not only unnecessary, but an injury."

REMARKS.—I regret to differ from the eminent and mysterious authority here referred to, but as I possess a practical knowledge of the locality in question, I am still of opinion that the pile foundation I arranged is the best that could be devised.

The Contractor's Engineer at first submitted a plan of an abutment founded on a simple platform of timber and concrete two feet thick, to be sunk some eight feet into the slippery clay at the lowest or front side. The abutment had to act as a retaining wall to resist 37 feet of earth, and the pressure from behind on such material would have quickly toppled the whole over into the ravine. The approved plan was for an abutment, to be sunk eighteen feet into the clay, and then founded on piles driven twenty-five feet deeper until a firm substratum of gravel was reached; the heads of the piles being thoroughly waled and cross-waled with six by twelve timber, and well bolted together. The floor composed of three feet of good concrete, well rammed in between the wales, and carried one foot above the pile heads.

6. The contractor says: "All science and practice shew that bearing piles should be perpendicular, whereas part of these are on the slant, and part perpendicular."

REMARKS.—Bearing piles should be perpendicular, when the pressure upon them is in the same direction, as in the case of a pier. In this case where the pressure to be guarded against is largely from behind, and therefore oblique, piles should be driven obliquely to resist it. I am perfectly satisfied of this in my own mind, but in order also to satisfy my employers, I voluntarily referred the matter to Mr. Joseph Tomlinson, Engineer of the Department of Public Works, Ottawa, who is conceded to be the best authority on foundations in the Dominion. He fully bears out my opinion, (see his letter Appendix 15).

7. The contractor says: "On the 24th July, I wrote your Engineer informing him that the East abutment of Portneuf Bridge, and also the pier of the same on the Monday following would be ready for inspection."

REMARK.—Such notifications are always promptly attended to by myself, or one of my staff.

MASONRY.

1. The contractor states: "A new specification was made and issued on the line by your chief engineer, differing materially from the one attached to the contract."

REMARKS.—Only one specification was issued by me; it was identical with the Northern Colonization Railway contract specification adopted for this line, on the recommendation of Messrs. Baillairgé and Light, in a joint report, except that my specification was rather more explicit and decided some vague points, such as dimensions of bonds and joints; also, the using of Portland cement throughout, instead of common lime; this specification was unanimously approved by the Commissioners before being issued.

2. The contractor states: "Mr. Boyd, one of the general inspectors, again added to this specification; the inspection"

"tors changed it to suit their views, and so on. The result was no sub-contractor or foreman could know for one day what specifications to go by, or whose orders to follow. The work the inspector would approve, Mr. Boyd or Mr. Sutherland, the general inspectors would condemn, &c."

REMARKS.—Mr. Boyd positively denies having added to the specification, or did the inspectors ever deviate from it. (Appendix 2.)

3. The contractor says: "During the summer the chief engineer turned all culverts intended to be dry, to first-class work, equal to bridges, and to a great extent Portland cement was used. The contract specification, (see report of Baillairgé and Light, page 51), which clearly defines that Portland cement will only be used in first-class masonry. The Commissioners approved of the Engineer's recommendation, that culverts be made first-class masonry, and that Portland cement be used therein, and ordered the work to be done, &c."

REMARKS.—The original Seymour specification which was embodied in the contract with the Government, required that all structures exceeding five feet in height should be built in hydraulic cement first-class, (see letter to Commissioners, Appendix 19.) This was however modified in the hope that good dry masonry well put together would suffice, but it was found impossible to get Mr. Robert McGreevy, the contractor's brother and agent, to do good work; it therefore became necessary to insist upon the building of all structures over five feet high, as required by the above mentioned specification, which the Commissioners approved. At that early stage it did not matter to some of the sub-contractors what terms were contained in the specification of the Government Engineer, as they had, according to official reports of the division engineers, by their own acknow-

ledgment when reprimanded for doing bad work, a contract with Mr. McGreevy for a very different and inferior class of work, and were told not to pay attention to the engineer's specification. These sub-contractors said they could not build the work required by the engineers at their prices; hence, much of the delay in building culverts, and the difficulties the engineers and inspectors had to contend with before a good class of culvert masonry could be obtained.

4. The contractor says: "From calculations made according to the requirements of your chief engineer for the masonry of main structures, and also for the culverts being made first-class, and their dimensions largely increased, it will take 40,000 cubic yards of first-class masonry for the whole line, (old location,) or an excess of 15,000 cubic yards—to \$210,000."

REMARKS.—The final quantity of first-class masonry, will exceed the contract schedule some 10,000 yards. I am not responsible for this excess as the schedule quantities were arranged by my predecessors with the exception of 5,000 yards added by Messrs. Baillairgé & Light, to cover increased size generally, as well as extra depth in the St. Maurice and Bout de l'Île Bridges, which is ample.

5. The contractor says; "The St. Maurice Bridge alone, will have an increase of 4,500 cubic yards, as per present plans of chief engineer."

REMARKS.—The masonry in this Bridge when completed, will only amount to 4,500 yards; how then can it be in excess the same amount?

6. The contractor states: "The masonry involved by the increased raising of grades over and above provided by new contract, between Lorette, and near Portneuf, and which was ordered by your Government, on recom-

"mendation of Chief Engineer and Commissioners, has not been estimated as an extra yet, though perhaps it may have been included in monthly progress estimates, and "taken from the bulk sum, like many other item."

REMARKS. --The additional quantity of masonry, due to raise of grades between Quebec and Three Rivers, is 310 yards, value \$3,178, (see Appendix, 17). It has been returned in the contractor's monthly estimates. In the contractor's letter to the Commissioners of the 27th June, 1876, a copy of which was sent to the Government, this insignificant quantity is designated as "a large increase in culvert and bridge masonry," and "at a tremendous cost." The dimensions of the masonry now building are as small as is compatible with safety and permanence, and are much smaller than similar structures on the western division of the same Railway. Owing to the constant vigilance of the engineers and inspectors, the masonry has been latterly kept up to specification, and is generally of good quality, but this result has been arrived at only by a strict supervision, and an unsparing condemnation of all bad work, and is not due to any cessation of Mr. Robert McGreevy's, mischievous interference. The class of work the contractor was formerly in the habit of putting up, may be judged of by my reports and those of the divisional Engineers. (See Appendices, 16 to 23).

IRON BRIDGING.

1. The contractor states: "Clause 10 of contract says, 'The party of the first part covenants and agrees also to build Iron Truss Bridges of the best quality and most approved plans for the crossing of St. Anne, Batiscan, St. Maurice and Ottawa Rivers.' The then Treasurer, Hon. Mr. Robertson, to whom was entrusted the detail of the schedule, informed me when speaking of this item, that

"the sample of what they required was already erected
"over the Back River, on the Northern Colonization
"Railway."

REMARKS.—I cannot judge of what the Hon. Mr. Robertson may have said to the contractor; what he said to me was that he exacted first class work, and held me responsible for its execution.

2. The contractor continues: "That your Chief Engineer
"held the same opinion is evident, from the specification
"he issued to the manufacturers 13th October, 1875, (Appendix D D).

REMARKS.—I issued no specification to manufacturers. The contractor designates as "specification" a private memorandum which I sent to five American Bridge Companies, in order to ascertain *relative prices* for information to be laid before the Government. This memorandum, (Appendix 24,) the contractor obtained from one of the firms in question. The information was required for the following reasons: 1. It was proposed to increase the width of the spans at the St. Maurice and Bout de l'Ile Bridges, in order to equalise the expense between piers and superstructures. 2. I wished to ascertain accurately what would be the increased cost of iron over wood, as from its then extreme low price I intended to recommend iron for all spans above 50 feet, and in the memorandum I sent out, I asked for prices for nine different widths of span, from 50 to 230 feet. The spans, on the present work, according to the contract, were but of three widths, viz: 150, 160, and 230 feet. I could thus hardly have issued a specification for spans that had no existence. Besides, at that time, the contract had not taken effect, no commission had been appointed, and it would have been simply absurd to have issued a specification without the power to close a contract.

3. The contractor says: "Moreover the fact, that same specification is made from the manufacturer's specification who made the iron bridge on Northern Colonization Railway above referred to."

REMARKS.—The contractor's statement is incomprehensible; there was no specification, so there could be no similarity.

4. The contractor says: "On this specification I was prepared to furnish the new iron bridges which I believe covers all that is required for a first-class bridge, and had closed for their construction, when your engineer changed his mind and required Lattice Bridges, and after a few months' delay issued a second specification headed for Truss Bridges, but in the body demands Lattice."

REMARKS.—I had never recognised my memorandum as a specification, and am not answerable for what the contractor chose to assume. I have always considered Lattice Bridges the best, and I strongly recommended them in submitting my specification of 20th May, 1876. That I am not singular in this preference will be seen by reference to the letters of Messrs. Hughes and Fleming, (Appendices 25 and 26.) What the contractor is pleased to call my "second" specification is in reality my first. I headed it "Truss Bridges," a term equally applicable to lattice or pin connection bridges. The distinction between the two is in the fact that the former is fastened with rivets; the latter with pins and nuts; but both come under the denomination of Truss Bridges; though the contractor would make it appear that the Truss is a distinct class of bridge. The contractor is careful to suppress the fact that I condemned his specification on the 31st March, 1876. (See my letter, Appendix 27.) He based it partially upon my memorandum, which was no specification at all, nor ever intended for such. A comparison between my specification

of 20th May, 1876, and the contractor's (see Appendix 28,) will show how deficient the latter is in all those details, which are essential to a correct specification. See letter from Mr. Hughes, bridge inspector, Grand Trunk Railway, on these plans and specification, (Appendix 25.)

5. The contractor says: "Time passed on without any " decision from your Chief Engineer or the Commissioners."

REMARKS.—My decision was always fixed in favour of the lattices, for which my first specification of 20th May was prepared.

6. The contractor continues: "This state of matters continued on without any results till some time in September, " when another and third specification was fixed upon, " bearing date 18th September, differing materially from " the other two previous ones."

REMARKS.—The Government meanwhile decided that it would be unfair to exact lattice bridges for this road, as two pin-connection bridges, of very fair construction, had been erected on the Northern Colonization, before the contract came under Government control. I was accordingly directed to prepare a specification for pin-connections, and to send it to the contractor. This is what he terms my "third specification," in reality the second. At the same time I wrote to the President of the Commission, expressing that my opinion was still in favour of lattice bridges, as superior in safety and durability, although pin-connection bridges, when thoroughly made, answer well enough. I pointed out also the great importance of having these bridges made by a firm of good reputation, who manufactured their own iron, and I insisted on this as a condition, when agreeing to the change of specification. (See letter Appendix 29.)

7. The contractor goes on: "By this time the season for " contracting for those bridges had passed, and yet no de-

"finite understanding come to between the Commissioners and Chief Engineer as to what they required, or if they understood each other, the necessary order called for by clause 16 was not complied with, or communicated to me."

REMARKS.—The "season for contracting" had not passed; the price of iron bridging having remained stationary. There was a perfect understanding between the Commissioners and myself. There was no necessity for sending an order under clause 16, as the bridges now required were well within the contract.

8. The contractor says: "Endeavoring to facilitate matters, I requested manufacturers to submit new rates based on the lattice specification. The rates were so far in excess, owing to the overweights of what previously called for, that I could not close without requiring the proper order for the extra weight."

REMARKS.—At this time the new specification had been adopted and sent to the contractor, who therefore need hardly have troubled himself about fresh tenders for the lattice specification.

9. The contractor says: "On 10th October I submitted to your engineer strain sheets from a first-class manufacturer."

REMARKS.—These strain sheets were accompanied by a plan some 30 per cent. too light, which had several objectionable features. I therefore rejected them.

10. The contractor continues: "On 9th December he replied, making no satisfactory objection to them, but merely that they are not in accord with clause 4th, and sub-clauses 1, 2, 3 & 4, which simply means I had to submit names, which I positively declined to do; this

" clause is intended, like the steel rail clause, to throw me
 " into the hands of a ring of speculators, who are already
 " prepared for the result, and understand how things are
 " going. The interest of the road requires a first-class
 " bridge of the very best material, to a fixed specification,
 " strain sheets, tests, inspection, &c. Further than this
 " does not come within the power of your engineer, be-
 " cause it gives him the advantage of making use, if he so
 " desires, of the names to suit combinations of speculators,
 " thereby throwing me into the hands of one man, while
 " no better bridge is obtained."

REMARKS.—It is usual on all railways to submit the names of manufacturers; it was done on the Intercolonial, and clause 4, and the sub-clauses alluded to, are identical with the I. C. R. specification. They are very necessary to ensure good work; each manufacturer being required to submit details of his own system, enabling the engineer thus to judge of their respective merits, and to select the best. I have nothing to do with the contractor's suspicions regarding "a ring" and "combinations of speculators." My sole aim is "the interest of the road," and to secure "a first-class bridge of the very best material," for the furtherance of which desirable end it is my business to adopt such means as will prove most effective and beneficial to the public, regardless of the contractors pretended fears.

11. The contractor says: "On the 30th December, submitting strain sheets from another manufacturer. On the 3rd January he replies as usual, and to which I replied on the 5th instant, thus the matter remains till some understanding is come to, and I desire it soon; as already I will be obliged to pay more than I could have obtained them for at the proper time, viz.: between February and May last, and the market may yet go up."

REMARKS.—The strain sheets in this case were accompanied by no plan, specification, or other essential data required by my specification. It was quite impossible to judge what sort of bridge the contractor intended to build; had I accepted them, I should have been completely at his mercy as regarded details of construction; of course it was my duty to refuse them. From 31st March, 1876, till 30th December, (a space of nine months), the contractor has persistently endeavoured to evade his contract, and has thus himself caused the delay, of which he so bitterly complains. After the "Ashtabula" horror I notified the Commissioners that I would take no further responsibility in the matter of these bridges, unless the contractor furnished me with proper data to enable me to judge correctly of their designs. Shortly after this, he did submit satisfactory plans, specifications, and strain sheets from the firm of Clarke, Reeves, & Co., Philadelphia, first-class people, with whom a contract has since been closed, with my approval. The price of iron is about the same as it was; any risk however the contractor incurred in this matter he may impute to himself, as is the case in regard to other particulars connected with the road.

WOODEN BRIDGING.

1. The contractor says: "Specification of contract fully described the detail of the work."

REMARKS.—The specification did nothing of the kind; it was exceedingly vague, giving not one single detail, but requiring all to be done in conformity with plans and specifications to be furnished by the engineer.

2. The contractor says: "Following this up, plans and detail specifications of the sizes of timber, iron, bolts, &c., together with the live load per foot, factor of safety, tests, &c., was furnished me by late Chief Engineer of railway

" company. Contract given out to a first-class bridge builder in accordance with the company's requirements, work proceeded with; all the iron and timber, &c., required for those between Quebec and Three Rivers, was prepared and delivered on line, those from Quebec to La-chevrotière inclusive were framed, ready to put up (Cap Rouge being up) and approved of."

REMARKS.—The specifications given out by the late Railway Company were fifty per cent lighter than the standard now adopted, which is as light as is safe; further the old specification is modified by the clause in the new contract, which binds the "contractor to make all changes in plans, in conformity with Government requirements from time to time." The contract may have been given to a "first-class bridge builder," but it does not at all follow that the bridge was up to the approved standard; as already stated, the work was in some instances, some fifty per cent too light. The contractor got possession of the plans, and never allowed me to see them till 22nd December, 1876, although I had written to his Engineer on the 11th July, demanding them, and had constantly requested them verbally besides. I could not therefore have "approved" of work, of which I had never seen the designs. (See my letters in Appendices 31 to 34.)

3. The contractor says: "In March, 1875, the Railway Company referred to Messrs. Baillairgé and Light, for their report on the class of road. In their report no reference is made to these bridges as requiring any addition or change though all the plans, specifications, &c., were before them, and Cap Rouge framed."

REMARKS.—Messrs. Baillairgé and Light made no reference *at all* to the bridges as their attention was not directed to them. (See joint report, Appendix 4). I never saw the plans and specifications till December, 1876, Cap Rouge

was framed, but not raised; a mere pile of timber at the time of our report, and covered with snow.

4. The contractor continues: "When present contract was made no reference was made to them further then substituting iron bridges for the principal rivers. The schedule rate was fixed for that class of bridge."

REMARKS.—No reference was made to these bridges more than to any other item of the road. They were included in the general clause above alluded to, which binds the contractor to make all changes required by the Government, &c. The schedule rate was fixed for no particular kind of bridge, beyond a good one, in conformity with contract.

5. The contractor says: "After a long delay your engineer now wants changes in those bridges, almost double their present rate. He has given the bridge-builder a certificate accepting them, but refuses to return them in estimates to me. No doubt the contract empowers changes to be made, but clause 4 of contract directs their payment, and clause 16 the order. (See letter from Chief Engineer and reply thereto.) While he admits by the letter that the additional work should be paid, and orders it to be done; his allowance is below the value."

REMARKS.—I have already stated that I could not get the plans from the contractor; he is therefore to blame for the delay, as the necessary changes would otherwise have been at once decided upon. I merely gave the bridge-builder, at his own request, a certificate that he had fulfilled his contract with the contractor; it does not at all follow that I considered the work up to standard, which it was not, being some 50 per cent. too light. I did not at all admit in my letter to contractor that the change should be considered as an extra; I merely stated, while ordering it, what would be its cost. (See my letter, Appendix 34.)

6. The contractor further says: "I want to be paid for all the additions, without any deductions for materials, not used by the change."

REMARKS.—I do not for a moment doubt the accuracy of this statement. Who can?

7. The contractor states: "Much valuable time has been lost by those new ideas introduced at so late a period of the work."

REMARKS.—There has been no loss of time but what the contractor is himself answerable for, and caused by his repeated attempts to evade his contract. (See my correspondence on Wooden Bridges, in Appendices 31 to 34, especially letter of July, 1876.)

8. The contractor says: "Contract empowers changes to be made, but clause 4 of contract directs their payment, and clause 16 the order."

REMARKS.—The changes in question do not require "payment," as they are only such as the contractor is bound by clause 1 of his contract to make, "from time to time, in conformity with Government requirements."

MACHINE SHOPS AND ENGINE HOUSE.

The contractor says: "On 13th June I wrote Commissioners that I had submitted plans to the Chief Engineer for those buildings at Quebec, and requesting him to decide on the location. No decision yet, though it will take more than one season to construct them."

REMARKS.—The decision does not rest with me. They can be easily constructed within one season.

PASSENGER STATIONS.

1. The contractor says: "The schedule allows \$60,000 for the three principal stations, Quebec, Montreal and Three Rivers. I employed an architect (Mr. Lepage) expressly to make plans for buildings; and submitted to your Engineer-in-Chief plans of Quebec station, which would have come within the sum appropriated. The general plan was accepted with considerable changes and additions."

REMARKS.—The "changes and additions" in question almost amounted to a remodelling of the plan, which was entirely unsuited to the requirements of a railway station. The offices were ill-arranged, the upper story badly lighted (with only three windows, now changed to seven,) the arrival shed without side-doors, and the baggage and express offices placed inside, on the Northern platform, instead of outside, as now placed—thus taking up half the space of the platforms, already too limited.

2. The contractor continues: "When the detail plans came to be submitted for approval, they were rejected, and others made by your Chief Engineer substituted."

REMARKS.—With the remodelled plan the specification had to be revised; the contractor was required to furnish enlarged plans of details; some were submitted, which were unsuitable, and the larger portion had to be entirely prepared in the Government Engineer's office. They are in keeping with the approved plan and specification.

3. The contractor states: "The details so made and sent to the inspector were not in many cases adapted to the building, the foundations of which were in, the year previous, nor to the general plans submitted."

REMARKS.—Every part of the building is in keeping with itself and the approved design, as can be ascertained by an examination.

4. The contractor further says: "Alterations, changes, "new plans, putting up, and taking down were daily and "hourly resorted to; no plan sent in by Lepage would be "accepted, so much so that I lost entire control of the "building."

REMARKS.—The main plan, as arranged by me, has been (with one slight exception,) strictly adhered to. Mr. Lepage's details were rejected because they were unsuitable. "Putting up" and "taking down" has been constantly resorted to, owing to the negligence and inefficiency of the contractor's people, scarcely a day passed without a complaint from the inspector of some attempt to put in inferior material and work, which *had* to be taken down. (See appendices 35, 36, 37 and 38.

5. The contractor says: "Roof of a construction and "weight fit for three buildings."

REMARKS.—The roof was designed by the contractor; I disapproved of it as being heavy and expensive; it was of the A form, and saved several feet of side walls. Had I condemned the roof, the walls would have had to be raised, so the expense in either case would have been pretty nearly equal. Not wishing to condemn all the contractor's work, I retained the general form of the roof, only altering it, sufficiently to make it useful and safe. As first designed, the principals were composed of timber 4 x 12 placed every 4 feet on the side walls, without reference to the openings for doors and windows where no proper anchorage could have been secured. The side walls had been designed in the office of the old Company, and were scientifically arranged with heavy pilasters at every 14 feet 7 inches, to receive the feet of the

principals, which arrangement the contractor's design completely ignored. I therefore increased the sizes of the principals 50 per cent, or to 6 x 12, and placed them 14 feet 7 inches, or 360 per cent further apart, or above the pilasters, where they could be properly anchored; this of course necessitated the usual arrangement of purlines and jack rafters. It is now a good roof, but owing to the peculiarity in the construction of the principals, which had to be cut half away at their intersections, it is necessarily much heavier than a roof with a horizontal tie beam would be. I warned the contractor of this fact, on the 21st May, 1876, at a meeting of the Board, called to approve of the plans, and advised him to substitute an iron roof, which would be much lighter and cheaper. He replied, that owing to the change from wood to iron in the bridging, he had a quantity of timber on hand which he wished to utilise. Had the roof been built as first designed by the contractor, it would have been very liable to fire, from the fact of the timbers of the principals being laid so close together; in any case it might have been almost termed a solecism in architecture. The actual difference in weight between the defective roof, and the one now built is six tons or fourteen per cent as will be seen by the following note from Mr. Boyd made at the time.*

6. The contractor says: "The appearance and convenience of the building has been seriously injured by insisting upon taking down the stone walls previously

*"The excess of cost of the roof for the Palais Station on the plan approved over that of a roof according to the plan submitted by the Contractor will be \$120.00 as shown by the following estimate."

5,750 feet B. M. more timber @ \$40.00 per M.....	\$230.00.
1,100 lbs. less iron @ 10c. per lb.....	110.00.
	<u>\$120.00</u>

The difference in weight is about 6 tons, or say 14 per cent.

J. E. B.

" put up to over one foot, thereby bringing down the floor
" on ground level, below the surface of the ground."

REMARKS.—One foot was taken off the foundation walls, which had been laid before the work came under my charge, and which were one foot too high to suit the established grade of the station-yard. I was reluctant to do it, and consulted the Board about it, but it was found that the higher level would have to be carried all over the station-yard, as well as the crib-wharfing; it was therefore judged better to reduce the foundation walls, and the building is still high enough for all practical purposes.

7. The contractor continues: " I did all that was possible
" to prevent this being done, but to no avail, and its cost,
" up to now is \$30,000, though only \$16,000 has been
" allowed in the progress estimates."

REMARKS.—The contractor's meaning is here more than usually obscure; the reduction of the walls did not cost thirty dollars. It says little for the contractor's management, if the building is to prove so costly. At this time, when labor and material are cheap, it should not cost more than the estimated value, viz.: \$20,000; and I very much doubt that it will actually cost as much. The body of the building is as small as can answer for a terminal station; all the work, though substantial, is very plain. The arrival shed is 164 x 58 feet, and therefore only long enough to admit one passenger car behind the engine and baggage car. It ought to have been 100 feet longer, so as to admit three cars, but this would have overrun the estimate; and the shed can be lengthened at any time. (See Appendices 35 to 38.)

ROLLING STOCK.

1. The contractor says: " On the 14th October, 1875, I
" submitted to your engineer specifications of Passenger

" and Freight Engines, as provided by contract, nine passenger and seven freight, 15 x 22 cylinder for former, and 16 x 24 for latter; after careful examination he approved of them. I gave the contract to the Portland Locomotive Company, a first-class establishment, of high standing and reputation. They proceeded with them according thereto, till the inspector's visit for their approval, when several changes, additions, &c., were insisted upon by the Commissioners, the approved specification thrown aside, and all, except four of them made, were to be 16 x 24. The extra cost by this change, including vacuum brake, will be \$800 each."

REMARKS.—I approved of the specifications generally, but reserved the right of altering details, (see Appendix 39). Twelve of the locomotives were made, on my recommendation, 16 x 24 cylinders, which rendered them more serviceable in the winter season. The contractor is careful to suppress the fact that the specification he gave to the superintendent of the Portland Locomotive Works, was *not* the specification approved by me, but an entirely inferior one, of which I knew nothing, and by which the work was depreciated just the amount he quotes on each locomotive, viz.: \$800; thus, the "addition" the contractor complains of, is simply what was required to bring the work up to the standard of the approved specification. The superintendent of the works in question himself informed me of the substitution of the specification made by the contractor, and I at once notified the Board of the fact.

2. CARS.—The contractor states: "After the specification on which I made the contract with the manufacturers had been approved of, this class of work is costing me 50 per cent. over the schedule price, because at the time the contract was made a more moderate class of rolling stock was intended than is now exacted."

REMARKS.—I approved of the specification on which it is said the contracts were made with the manufacturers, on the distinct understanding that it was to be according to the *latest* Grand Trunk standard, and I made my approval dependent on this condition. The contractor professed to be willing to conform to my stipulation, but at the same time issued his own specifications, which are of an entirely different and interior character. I was unable for some time to detect the imposition, as the contractor, in direct violation of his contract, neglected to furnish me with plans, and I had therefore no means of judging of the genuineness of the specifications. He persistently disregarded my constant demands for such plans, but gave me at last copies of specifications, which I submitted to Messrs. Blackwell & Wallace, G. T. R. superintendents. The letters of these gentlemen (see Appendix 39) state that the contractor's specifications were not according to G. T. R. standard. I directed attention to my reports to the Commissioners, (see Appendix 39) in which will be found, at length, the whole facts of the case.

3. The contractor continues: "The manufacturers are complaining that the orders of the inspector differ and clash repeatedly with the specification given him by the Chief Engineer, who on his part has already given several differing from each other during construction."

REMARKS.—This statement is quite contrary to fact. I have never given any specification at all to either the inspector or the contractor.

PILES BRANCH.

The contractor says: "Believing that it was within the scope of my power and duty, under the contracts, to locate and build a line within the quantities and sum provided for this Branch, I sent out a party to complete

"location, this I was, as already stated, prevented doing.
 "It now appears that, from the Commissioners' location, if
 "yet finished, fully 100,000 cubic yards of excavation will
 "be required on this line more than provided by contract
 "schedule, and this in a part of the country which will be
 "either very hard class of earth or rock, &c."

REMARKS.—The position taken by the Commissioners with regard to the location of this road is correct; the contractor has no "power" to locate a line. The location chosen, is moreover as good a one as the country will admit. I did not arrange the schedule quantities.

ESTIMATES.

The contractor says: "No proper monthly progress estimate as provided for by contract has been made or paid me since the present contract was signed. Every month between the 15th and end of month, sums of money would be handed me, without an explanation as to the proper balance, or based, as far as I am aware of, on any properly made estimate of the work done, and materials delivered. When later a copy would be given me the omissions of work done and material delivered, were so great as to be a serious matter * * * *"
 "I have repeatedly called the attention of the Commissioners and the Chief Engineer to these omissions, but to no purpose."

REMARKS.—Every item of work done and "materials delivered" by the contractor, has been duly returned in the monthly estimates, by myself and my staff. I know of no omissions in these estimates, as can be substantiated by reference to the monthly returns of the Division Engineers, who are directed to return accurately the amount of work done, material delivered, and value thereof, according to established schedule rates.

CONCLUSION.

I have now noticed the Contractor's statements in their order, and it remains for me to review the subject, in its true bearings upon the work. Touching "delay" the Contractor observes at the close of his pamphlet. "The object 'your Chief Engineer could have had in so delaying the 'work I am unable to say, if it was for the purpose of keeping the work back to have it spread over several years he 'has fully carried his point.'" In reply, I state that I have voluntarily recommended to the Government, a line between Maskinongé and Montreal, (60 miles in length), which will occupy two years less time in construction, than the one (via Bout de l'Isle) previously contemplated. This line has been approved by Mr. Fleming in a report on the subject, in which he states that its adoption will save an expenditure of half a million of dollars to the Government. Further, I call attention to the following facts: On division No. 2 of this road (50 miles in length) there were, up to December, 1876, but 258 yards of dressed stone delivered, and out of 18,673 yards of masonry, only 1,760 yards completed, leaving 16,913 yards yet to do, on the division, including the St. Maurice Bridge. The masonry is the heaviest portion of the work, and governs the time of completion, the grading of the road being so light that an energetic and experienced contractor could have completed the whole of it between Quebec and Montreal, in one season. The work has been in this contractor's hands for three years; during a year and a half of this period, it has been under Government control, with monthly cash payments at fair rates, for all work done, material delivered, and ready for delivery. The divisional engineer reports, (see Appendix 13), on the 13th December, 1876, (the close of the working season), that but little progress has been made owing "to a great want of energy in pushing forward the masonry," but that "strenuous efforts" were to be made by the contractor this winter, to

get out all the stone needed to finish the work. The extent of these "efforts" can be appreciated by the fact that up to 31st March, 1877, (the close of the hauling season), Mr. Hamlin's returns (Appendix 13) shew that there have been 1,324 yards of cut and 2,008 yards of rough stone delivered, or less than 20 per cent of the quantity required; there are still 1,100 yards of cut, and 1,158 yards of rough stone in the quarries, miles away from the work. The delivery of stone in the summer season is made almost impossible by the bad state of the roads. At this rate of progression, the work may possibly be finished in five years, but the facts show that the Government Engineer is not, at any rate the party, interested "in keeping it back."

The contractor began the St. Maurice Bridge some three months ago, and has already made mistakes that will prevent its completion this year. That it could have been completed with proper management, will be seen by the letter of Messrs. Macfarlan and Macrae, practical bridge builders. (Appendix 12). The foundations of the two deep water central piers should have been put in through the ice this winter, but the contractor, disregarding my advice to this effect, (see letters Appendix 12) has confined his attention to the two shore-piers, which are of less importance. Of these two, he has put in the foundation of the western pier successfully according to the suggestions I gave him, but with the eastern pier he has acted in opposition to my advice, and has persisted in sinking the masonry at an unseasonable time of year, on piles some of which project eight feet above the river bottom; the caisson having no outside protection, it was impossible for a diver to go down at that season to arrange the foundation. It is thus left in a precarious position, and will cost a great deal of money to render safe. It is my business to approve the plans of foundations and masonry, but the contract gives me no

control over the contractor's mode of getting in the works, and though gravely objecting to his proceeding, I could hardly stop it, without incurring a charge of unnecessary interference.

The contractor would make it appear that constant changes have been made by me on the works, especially as regards the structures. I can show that on upwards of two miles collectively of varied and difficult bridging (both wood and iron) requiring for the most part artificial foundations, not to mention numerous large culverts and small structures, there has been but one change made by me, after the plans had been approved; this was in the foundation of Batiscan Bridge, where the borings taken had proved so fallacious. Deep-water foundations are always more or less uncertain to deal with, even where careful borings have been made, and it is difficult to judge of them properly until they have been "unwatered." In the case of Portneuf Bridge, plans were made, and the work set out (although situated 36 miles distant from head-quarters,) 24 hours after I had received the proper borings from the contractor. In connection with this subject, I will allude to a letter from Mr. Robert McGreevy, the contractor's brother and agent, in reply to one of mine of the 20th July, 1876, directing his attention to some important facts connected with the work, (Appendix 14). The contractor's agent says: "Ever since the signing of the contract in "September, 1875, "I have repeatedly urged you for a "decision respecting this structure," and "on or about "the 28th April, I renewed my entreaties, knowing well "that especially with this structure, not a day was to "be lost. At this conversation you expressed a wish to "have an iron trustle viaduct, or an iron truss bridge over "the Portneuf river, either of each you would prefer to the "present structure as provided for in the contract." No official communication passed between the contractor's

agent and myself, on this subject, until the 14th February, 1876, on which day, not "on or about the 28th April," he called with their engineer to submit a plan for the structure which the latter recommended, but which I condemned as impracticable. I advised that borings should be at once made, and I expressed a preference for an iron superstructure, but said that whether wood or iron, the quantity of masonry would be the same; but if the hill-side should prove to be rock, a trestle viaduct would be the cheapest. This conversation I embodied in a letter which I gave to the contractor's agent shortly after. He again remarks: "It now appears by your letter that borings will still be necessary though to what purpose I, or any other person connected with the work cannot see, as the excavation of the east abutment shews clay of the best kind, quite compact and safe, the pier cannot have a better foundation than what is now laid bare. It is however gratifying to find you come even at this late date to what you then refused, and delayed the work until now, *i. e.*, boring tools of the usual kind for the east abutment. Had you accepted the borings by these very tools three months ago, the work would have been more advanced." The question of borings has been already discussed in my remarks on contractor's "statements," but I take occasion to repeat that no borings had been made here, unless the contractor's agent designates as such, a sounding of the surface by a crowbar; "boring tools of the usual kind," even, not having been used. The clay was of the worst description that I have ever seen, and formed a very bad foundation. Since the date of my conversation with his agent, the contractor had excavated a foundation-pit, at the East abutment, to the depth of 18 feet, it was necessary to ascertain how much farther the clay extended, and as it was soft enough to admit of penetration by anything, I told the contractor's agent that the ordinary tools would suffice. He used these tools accordingly, and bored a few feet,

when he was stopped by a vein of hard sand, and had finally to obey my original order, and apply the proper implements, such as I had recommended on the 14th February, 1876. The contractor's engineer also submits a letter on the same subject, but I do not notice it, as the points it contains have been already discussed.

The correspondence produced by the contractor, in support of his statements, is unreliable; facts are either distorted or suppressed to suit his convenience; and in one instance he has not hesitated to resort to fabrication in order to bolster up his case. I allude to a letter, published in his appendix, purporting to be from Messrs. Munro and Stears, sub-contractors for a number of sections, including Portneuf Bridge, wherein they are made to observe. "The cause of this great delay was a number of plans received from the Government Engineer, and a want of decision on his part as to how the foundations were to be put in." I append a letter from these gentlemen, (Appendix 40) in which they state that "they never received any plan from me," and that the only plan they had was from the contractor's engineer. Further, in my presence and that of Messrs. Lindsay & Hoare, (Appendix 41) they qualified the letter contained in the contractor's pamphlet as a "gross forgery," and stated that the delay was entirely caused by the contractor's neglect in furnishing them (as agreed) with stone to proceed regularly with the work.

The contractor also produces a letter to his engineer, from Mr. Boyle, divisional foreman, wherein it is stated that "great losses and delays have occurred over a considerable portion of the line through the work not having been set out in season by the assistant-engineers." It should have been further stated that these assistants were employes of the contractor, nominated and paid by him, and amenable to his orders, and that the "losses and

delays" in question were mainly caused by the contractor's choice of inexperienced men, whom he overworked and underpaid, and whose travelling expenses he refused to allow, thus rendering the proper fulfilment of their duties a sheer impossibility in view of the extent of their sections and the narrowness of their salaries.

Again, the contractor publishes a letter from Mr. R. J. Flanagan, who states that "one of the causes of delay on the Batiscan Bridge was that through incorrect centres given for piers one and two, there was two rows of 36 feet piles driven out of place for platform, being 36 piles in each pier lost to work," and "through incorrect centres given for West abutment, it caused ten feet of unnecessary excavation." Here also the statement stops short of the facts; and it is no doubt more convenient to suppress the real fact that both mistakes were made by the contractor's Chief Engineer, (Appendix 42).

Before concluding my remarks, I wish to say a few words about the "steel rail clause" alluded to by the contractor in his pamphlet. I have always insisted that one uniform pattern of steel rail and steel fastening of the best pattern and quality should be adopted on the whole road between Quebec and Ottawa. This requirement the contractor has steadily combatted, and maintained that he had a right to purchase any sort of rail, provided it was steel. He refused (in direct violation of his contract) to give me any plans or specifications, but submitted for approval a section of one rail of a bankrupt lot (2,700 tons), which he was about to buy in Liverpool. I at once notified the Board that the proceeding was unusual and wrong, and I promptly prepared a plan and specification of a steel rail and steel fastening, which I advised should be adopted for both the Eastern and Western divisions of the road; it was approved and adopted accordingly, and the contractor was notified

to abide by this standard. Nevertheless he concluded his negotiations with the Liverpool firm, which were only nullified by the Commissioners acquainting his banker that the rails would not be accepted, and forbidding the advance of funds for their payment. The uniform and excellent pattern of rail now in use on both sections of this road was thus secured. The rails were contracted for at prices of which I had no knowledge, and the names of the several manufacturers are only known to me through Mr. Sandberg's (the inspector) returns. So much for the contractor's charitable suspicion that the "steel rail clause is intended to throw "him into the hands of a ring of speculators." I append my specification and that of Mr. Sandberg with the correspondence on the subject. (See Appendix 42.) *

The contractor has throughout endeavoured to impose inferior articles upon the Government, and I have often been too experienced and decided to suit his views, regarding all those essentials on which the excellence of a railway depends, viz.: an elevated grading; a properly specified and inspected steel rail and steel fastening; safe foundations; good masonry laid throughout in Portland cement; sufficiently strong iron and wood bridging; proper stations; uniform rolling stock, and a well-laid track, properly sleep-ered and ballasted with *gravel*. He would no doubt prefer that I should be both unfit to distinguish and ready to approve: slop-rails and iron fastenings; unsafe foundations, attempted at St. Maurice, Batiscan and Portneuf bridges;

* It will be seen that Mr. Sandberg altered my specification by omitting to hammer the blooms, and by punching instead of drilling the bolt holes, which alteration I consider was no improvement. Blooms are always hammered, and bolt holes drilled by the best railway companies in the United States. The Engineer of the Pennsylvania Central, informed me, that the company had suffered so much from accidents owing to the bolt holes being punched, that they now drilled all their rails in the main line, at a cost of fifty cents a ton—while the cost of hammering was one dollar per ton, which he considered a small price to pay for safety.

indifferent masonry, laid either in lime mortar, or equally worthless cement; bridges of iron and wood 50 per cent. lighter than as now approved; insufficient station accommodation as designed for the Palais; second-class rolling stock as at first delivered; and a wretched track ballasted with sandy loam from the adjacent cuttings, making an inelastic, dangerous and dusty road. Excellent gravel can be had at convenient intervals, at an average lead of $\frac{1}{3}$ of a mile from the line. (See Appendices 46 and 48.) Had the contractor been allowed his own way in regard to these particulars, the result to the Government would have been a second-class road. I do not hesitate to say, in closing my remarks, that all "difficulties," "delays" and "losses" that may have occurred in the prosecution of this work have been caused by the contractor's mis-management and want of energy, and by his persistent efforts to evade his contract. I am moreover of opinion that the work cannot progress favorably under Mr. Robert McGreevy's ignorant supervision. His underhand interference with the engineer's orders is in direct violation of the contract, and is productive of the most disastrous results to the work, as will be best seen by the letters appended. (See Appendices 7, 8, 19, 44, 45, 46 and 47.)

Having thus endeavored to destroy the web with which the contractor has tried to hide his own faults, and to throw upon others blame justly imputable to himself, I shall leave the questions at issue between us to your decision, confident that towards him as towards the public who are mainly interested, in this important Railway, I have never failed to do my duty impartially and conscientiously.

I have the honor to remain,

Gentlemen,

Your obedient Servant,

A. L. LIGHT.

M. Inst., C. E.

APPENDICES.

APENDIX No. 1.

ENGINEERING AND INSPECTION.

Quebec, 30th January, 1877.

DEAR SIR,

In a pamphlet lately shown me, and published by Mr. McGreevy, there is a clause under the heading of Engineering and Inspecting, in which it is stated that the number of inspectors of masonry employed on the work last season was so great that they did not average more than five miles of line upon which to exercise their supervision; as this statement reflects somewhat upon myself, I take the opportunity of saying that my division is 54 miles in length; on this extent of line, I had, for the greater part of the summer, only five inspectors of masonry, but some time in September, it was thought advisable to employ Mr. Sutherland, making at the latter part of the season altogether six inspectors, which divided into 54 would give nine miles each, which is quite as much as any inspector can do with justice to himself or to his employers, but out of this number as you will see by the annexed statement of their distribution, there was one exclusively employed on the St. Anne's bridge, which required all his attention. There was also one appointed for the Portneuf bridge, which would have occupied all his time had work on that bridge been prosecuted vigorously and continuously, but there were several stoppages in this structure for want of steam, which enabled this inspector to superintend the construction of culverts over ten miles of line. You will thus see that the distribution of the inspectors was as judicious as could be done, and that most of them had upwards of twelve miles to inspect. Mr. Sutherland was not employed at a large salary as stated in Mr. McGreevy's pamphlet, but only received the same pay as the others, \$75 per month.

Then again it is mentioned that on the Intercolonial Railway there was only one inspector to every division of

twenty miles, as I was employed on two of these divisions of the I. C. R., I can say, and you are aware, that on each division two inspectors or one to every ten miles at large salaries of \$110 per month were appointed.

The following is the distribution of the inspectors on my division of this road.

Augustin Trépanier, from Quebec to St. Augustin or Cap Rouge River.....twelve and a half miles.

James Sutherland, from Cap Rouge River to Pont Rouge.....twelve miles.

Alfred Bart, Jacques Cartier Bridge and culverts from there to Portneufnine miles.

Pierre Gauthier, Portneuf bridge and culverts between there and Grondines.....ten miles.

François Bocage, culverts in the parishes of Grondines and St. Annes.....ten miles.

Charles Dugré, St. Anne's bridge alone.

Yours truly,

(Signed,) JOHN LINDSAY.

APPENDIX No. 2.

Three Rivers, 20th February, 1877.

ALEXANDER L. LIGHT, Esq., C. E.

Chief Engineer, Government Railways, Quebec.

SIR,

I beg leave to submit the following reply to the allusions made to me at pages three and six of Mr. McGreevy's pamphlet.

1st. There was never any difference between the orders given by the divisional engineers and those given by me. We were in constant communication, frequently went over the line together and were thoroughly in accord on all subjects connected with the works. I never set aside the divisional engineers orders, the contract or the specification.

2nd. Mr. McGreevy is mistaken in supposing that I added to the specification. Soon after receiving the specification, I noticed that in second-class masonry the bond and the return of vertical joints were not mentioned. I suggested to you that in order to ensure *uniformity* of practice among the inspectors, it would be well to define the bond and joint for second-class masonry. On receiving your orders respecting these points, I wrote them in the margin of the inspectors' books.

3rd. The inspectors had no power to alter the specification "to suit their views," and I do not believe they did so, as the jealousies among the sub-contractors would soon have led them to call my attention to any difference in practice had such existed. I was continually on the line, and took pains to keep all the work up to the same standard, and I believe that on the whole the inspection was carried out in a fair and equitable manner.

I have the honor to be,

Sir,

Your obedient Servant,

(Signed,)

JOHN ED. BOYD,
Inspecting Engineer.

APPENDIX No. 3.

GOVERNMENT ENGINEER'S SUPPLEMENTARY
REPORT ON NORTH SHORE RAILWAY.

Quebec, 12th January, 1875.

TO THE HONORABLE P. GARNEAU,

Chief Commissioner of Public Works, &c.

SIR,

In accordance with your letter of this date, I herewith send you the substance of a report prepared (sometime ago) at the special request of yourself and the Hon. Mr. Church, that I would state "categorically any reasons for considering the North Shore Railway not first class." In this report I recapitulate certain objections to the work, which although, not all stated in my first official report, have been mentioned to yourself and other members of the Government as well as to the President of the Company :

1st. As most important. The road bed between Quebec and Three Rivers is laid entirely too low, and narrow, to be continuously and economically worked in this climate.

2nd. The culverts, or water passages through the embankments are built upon imperfect plans, the masonry extending but two feet below a surface exposed to frost, the rough hammered side and end walls of these structures being founded on a paving of rough stone averaging a foot thick (which extends over the whole base of the structure including the water-way) instead of being sunk from two to three feet below the level of this paving, as is usually done, where permanent work is intended. Paving laid, as in this instance, without apron walls, at each end, extending some depth below it, is liable to be undermined, and thus destroy the superstructure. Frost in this climate penetrates from three to four feet, and upheaves walls, on

earth foundations, not sunk below its influence. Culverts therefore, not thus founded, unless with a continuous stream flowing through them, are liable to fail.

3rd. The masonry in the bridging although apparently good of its kind, is generally too small, the piers especially; those intended to carry spans of 160 feet are but five feet thick, or fifty per cent too thin, to bear the great vibration caused by trains running at high velocities, over these large spans. The only pier as yet completed, viz:—That on the west side of Jacques Cartier River, designed to carry two spans or 300 feet of superstructure, is but four feet six inches thick, at under side of coping.

This pier is founded on rock, which from its want of elasticity, like the stone sleepers on the old railways, will augment the shattering effect of passing trains, that will surely wreck it sooner or later, especially as there are no through stone,—with the exception of the coping,—passing from side to side, in the body of the work, and the cementing matter used in its construction is *very weak*. The usual thickness of piers in similar situations on well constructed works, is not less than seven feet.

4th. The proposed plan of founding piers on soft bottoms, in the deep waters of the larger rivers, which in some instances are 25 feet deep at low water, although economical, I consider hazardous. The mode proposed is to build the masonry on a platform, placed upon piles, driven in three feet squares, and cut off four feet under low tide level. These piles being inclosed within a crib of round logs, notched and bolted together, laid partly open, and filled with loose stone. Should the surrounding crib settle, or a jam of ice or logs break the enclosure, contingencies very probable, the pier would be destroyed.

5th. The superstructure of many of these bridges especially from Quebec to Portneuf, is much longer than the waterway of the streams require. This while greatly reducing the permanent items of earth work and masonry, involves expensive periodical renewals, that would otherwise be avoided.

The same objection applies to the trestle work on which a portion of the railway is to be laid.

6th. The cement and sand being used at Portneuf bridge, the only place I found masonry in progress, were very indifferent—indeed quite unfit for the work, as I pointed out to the resident engineer.

These remarks are outside of the question as to whether steel rails and iron bridges are or are not at the present day, part of the equipment of first-class railways. They would have been noted in my first official report; but it was preferred to mention some of them verbally, rather than raise so many objections on a first inspection of the work.

I have the honor to be,

Sir,

Your obedient Servant,

A. L. LIGHT.

APPENDIX No. 4.

REPORT OF CITY AND GOVERNMENT ENGINEERS TO THE SPECIAL COMMITTEE.

Quebec, 13th March, 1875.

A. H. VERRET, Esq.,

Secy. N. S. Ry. Co.

SIR,

In accordance with resolutions passed on the 3rd and 12th instant, respectively, at meetings of the Special Committee of the North Shore Railway, wherein Messrs. Baillairgé and Light were requested to come to a mutual understanding and make known, with the least possible delay, what modifications are necessary to be made in the specifications and in the plans of the road, to render it acceptable to the Government and the Corporation as a first-class railway, taking into consideration, however, the resources at the disposal of the Company for the construction of their road. Messrs. Baillairgé and Light beg to report on the above as follows :

1st. That the road bed (or base of ballast) be raised more or less equivalent to an average of at least one foot throughout its entire length.* With regard to this raising of road bed, we suggest that the whole line be passed over profile in hand, and the points where the raising should be made, be indicated on that profile.

2nd. That the cuttings be increased from 18 to 24 feet in width, to admit of thorough drainage.

3rd. That although Messrs. Fleming and Light are decidedly of opinion that a width of 17 feet at "Formation" or base of ballast level, would insure more permanency, safety and ultimate economy ; yet taking the present resources of the company into consideration,—we are pre-

pared to recommend that a width of not less than 15 feet, as now arranged for the Montreal Northern Colonization Railway, be adopted, as the width of "Formation Level" on the North Shore Railway—it being understood, that the road bed shall be so made, that it will retain the full width of 15 feet, after it has thoroughly shrunk and consolidated. Where the native material is sufficiently good to be used as ballast, the road bed may be raised or left one foot higher, and reduced to 12 feet in width, at underside of sleeper.

The undersigned are induced to recommend this reduction, because these embankments can be *widened* hereafter, if desired, without interfering, materially, with the general plan of the Railway, whenever the resources of the Company will admit of this increase.

4th. That a foot of ballast be placed under the sleepers as well as carried up to the level of their upper surfaces, as shewn in the diagram attached, the width of ballast being 10 feet at the level of top of sleeper, and 14 feet 6in. at Formation level.

5th. That the top width of piers shall in no case be less than from 5 to 7 feet for spans of from 80 to 160 feet, 5 feet for spans of 80 feet, 6 feet for spans of 120 feet, 7 feet for spans of 160, and proportionately for intermediate or larger spans, which, of course, will necessitate the rebuilding of the pier at Jacques Cartier Bridge, in conformity with this suggestion, or the erection of an additional pier. Also, that the additional thickness required at the piers of the bridge at Porneuf, of which the foundations are already in place, can be obtained by altering the batter thereof. †

That these piers be constructed of first-class masonry, Mr. Light being of opinion that the specifications for masonry, in use on the Montreal N. Colonization Railway, owing to their freedom from ambiguity, be adopted on the North Shore Railway, and that Portland hydraulic cement be used in all first-class masonry, in the proportion of two of sand to one of cement in face work, and three of sand to one cement in the backing and hearting. ‡

6th. That the foundations for piers in deep water shall be so altered and strengthened to the approval of the undersigned as to ensure that safety and stability, which, in

their opinion, they do not now possess. This modification (clause No. 6) we are of opinion is clearly within the scope of the contract. §

We have the honor to be,
Sir,
Your obedient Servants,

CHS. BAILLAIRGE,

A. L. LIGHT.

N.B.—These modifications were unanimously adopted by the special committee, and accepted by the contractor. The following notes were appended to the copy of this report, when it was submitted to the Government, and recommended to be embodied in the present contract.

* In the estimate returned to Hon. Mr. Church, this raising of the grading has been assumed to increase the earth work but 500,000 c. yards, should the western half from Three Rivers to Montreal (access to the plans of which has been denied me by Gen. Seymour) be laid as low as that portion between Quebec and Three Rivers. This necessary elevation will amount to at least 750,000 c. yards, or to about 50 per cent on the original quantities of earth work.

† The additional masonry caused by changes and omissions are estimated by the present engineer of the Company to amount to 8,600 cubic yards.

‡ This change will increase the cost of the masonry about \$1 per yard.

§ Whether this last modification is or is not within the scope of the contract, the change in these foundations, simply to make them *safe*, will involve very considerable expense as the bottoms of most of the larger rivers have been found much more formidable than originally represented.

APPENDIX No. 5.

Clause No. 1 of Contract wherein the Contractor binds himself to make all changes in conformity with Government requirements.

The party of the first part hereby covenants and agrees to make all changes in grades, plans, specifications and otherwise in conformity with the Government requirements from time to time, as the said work progresses, and it is fully understood and agreed by and between both parties hereto, that the profiles, plans, working, drawings and detailed specifications of the different works, structures, buildings and equipments, shall be made by the said contractors and fully approved by the Government Engineer, before work is begun upon them, and that all work and materials shall be subject to his inspection and approval before being accepted and paid for by the Government. It is further understood and agreed by and between the said parties hereto, that the decision of the Government trustees or commissioners, upon the report of the Government Engineer, shall be final and conclusive as to all materials used or work done or in course of doing, which materials shall be of the best description of their respective kinds and satisfactory to said engineer, and such as shall ensure a first class road, which the said Honorable Thomas McGreevy, doth hereby bind and oblige himself to construct and deliver.

APPENDIX No. 6.

A. L. LIGHT, Esq., C. E.

DEAR SIR,

In reply to Mr. McGreevy's statement that the plans for abutments at St. Anne's and Batiscan Rivers, were altered in the Government Engineer's office, I have to say that the plans now in use were designed there altogether, the original plan first submitted by the contractor, was at once condemned by the Government Engineer, it was arranged on a T form of a most objectionable design, and the contractors spent a long time trying to force it into practice. The approved plan of the Government Engineer was 24 feet wide instead of 8 feet, as shown in the contractor's T abutments. Any alteration made in the design was merely in copings, string courses, arrisses, &c., to perfect the work, which was intended to be a standard, the plans were certainly sent back once or twice to be made suitable but the work was not delayed thereby, as the plans were certified and returned before the contractor was ready to commence operations. The contractor labours to prove that the substitution of a 4 for a 3 foot coping did not leave space for the trusses, ignoring the fact that the space was obtained by chambering the inner side of the coping.

I remain,

Yours truly,

E. A. HOARE.

APPENDIX No. 7.

ST. ANNE'S BRIDGE.

Quebec, 21st July, 1876.

HON. H. G. MALHIOT,

Chief Commissioner Q. M. O. & O. Railway.

DEAR SIR,

I am informed by Mr. Boyd that the contractor, notwithstanding orders to the contrary, has peremptorily notified his sub at St. Anne's to commence building the west abutment there on an uncertified **T** plan even more objectionable than the faulty one on which the east abutment has been partially built, and threatens, if the sub does not commence forthwith, that he will put on a gang on Monday to carry out the work.

This **T** form of abutment was arranged by the late Chicago Contracting Co.'y, and generally condemned in my supplementary Report of the 12th January, 1875, as being "too small and unfit for a first-class railway."

An enlarged and safer plan intended to be a general design for all such structures was prepared in this office, submitted to you, and approved. The contractor's engineer, was notified that this abutment was to be substituted instead of the objectionable **T** form, and furnished with the design for future guidance.

I have since received a letter, (see enclosure) to the effect that the contractor refuses to build this improved abutment, unless certain conditions are complied with, also alleging that the change will cause serious delays. This is a mistake, as the difference in actual work between one form and the other is but 75 c. yards, and requiring but ten additional piles in the foundation, say equal to two good days' work.

The performing of this work will occupy much less time than cutting off the piles at the bottom in Pier No. 1 still to be done, and which, from lying to the east of the work in question, will necessarily be first required.

The additional quantity of 5,000 c. yards of first-class masonry inserted in Schedule B over and above the quantities in the Seymour Schedule A. was for the express purpose of covering enlargement, and is amply sufficient.

The contractor's action is in gross violation of the contract, wherein he binds himself in the original North Shore specification, forming part and parcel of the new contract. "Firstly, That the work shall, in all cases, be under the direct charge and control of the engineer, and his orders must be complied with in every respect and under all circumstances"; and, secondly, in clause 10 of the new contract, wherein he agrees "to make all changes in conformity with the Government requirements from time to time as the work progresses," and that all plans "shall be approved by the Government Engineer, and that the decision of the Government Commissioners, upon the report of the Engineer, shall be final and conclusive."

The abutment which the contractor now proposes to build has not been approved, and it is not suitable for a first-class railway.

I remain, Dear Sir,

Faithfully yours,

(Signed,)

A. L. LIGHT.

APPENDIX No. 8.

ST. ANNE'S BRIDGE.

A. L. LIGHT, Esq.,

Chief Engineer.

SIR,

On Thursday morning last, Mr. Flannigan pumped out the foundation pit of the west abutment and handing Mr. Perrault a plan ordered him to begin his masonry. I said, "If you do, Mr. Perrault, you do so at your own risk, as I shall not have the work inspected." Perrault then decided not to begin. Flannigan stopped the pumps and the pit filled with water. Mr. McGreevy has since telegraphed to Perrault, that if he does not begin on Monday, he will put on a gang himself. Flannigan says he will again empty the pit and order Perrault to go on on Monday. I have given Dugré (the inspector) a written notice to hand Perrault in that event, to the effect that the plan sent him by Mr. McGreevy has not been approved by the Chief Engineer, and that as we are going to drive more piles, any masonry he puts in, may be so shaken that it will have to come out, even if it should fit new plan.

The plan Mr. McGreevy is contending for is *quite different* in many particulars from that of East abutment, and has some objectionable features, which, I am sure, you would not allow in any case.

Yours sincerely,

JOHN E. BOYD.

P.S.—I proposed the omission of the piling only to facilitate the work and not delay Perrault; but I agree with you the piling is the safest as a slight unequal settlement might crack the wing wall; 10 extra piles will answer.

J. E. B.

Quebec, March 21st, 1877.

A. L. LIGHT, Esq.,
Chief Engineer.

DEAR SIR,

Referring to a letter in Mr. McGreevy's pamphlet, (Appendix,) it might be supposed that I had been guilty of some great neglect of duty. I therefore enclose you a copy of my letter, to Mr. Odell, which called forth such a violent complaint to the Commissioners from Mr. McGreevy, which letter speaks for itself.

Yours truly,

JOHN LINDSAY.

(Copy.)

Quebec, May 18th, 1876.

CHAS. ODELL, Esq.,
Contractor's, Engineer.

DEAR SIR,

Your letter relative to setting out trestle work on the Island at St. Anne's River, came to hand this a. m., since which time I have communicated with the Chief Engineer, who desires me to inform you, that whatever trestle work you put in there, can only be temporary, and therefore will not require any particular setting out, moreover, that the grades have not yet been decided upon by the Commissioners, who have now under consideration, the doing away with the swing bridge.

Yours truly,

JOHN LINDSAY.

APPENDIX No. 9.

BORINGS, PORTNEUF AND ST. MAURICE.

Quebec, 14th February, 1876.

ROBERT MCGREEVY, Esq.

SIR,

With regard to the conversation had with yourself and Mr. Odell, to-day, on the subject of the Portneuf and St. Maurice River Bridges, to avoid mistakes, I would repeat that before definite plans can be satisfactorily arranged for either place, it is above all most important that correct borings be taken and sections plotted, shewing the strata composing the respective river beds.

In the case of Portneuf river, the nature of the material forming the valley should also be ascertained for about 250 feet along the centre line on each side. The borings should be taken at the margin of the stream and at intervals of every 50 feet. Those on the margin should be carried down 15 feet below the river bed, and those on the slope of the hill, as deep as the river bed. Without such borings, there is not sufficient data to found a safe opinion upon, and therefore I recommend they be made and submitted without delay.

With regard to the River St. Maurice, I have already expressed an opinion that the foundations for this bridge are objectionable.

Should borings and test piles—that should also be driven—exhibit that piles can be advantageously used, I would recommend they be cut off at level of river bottom, and the masonry sunk on them with caissons.

To enable the timber already provided, to be utilized, the caisson bottoms may be composed of *several thicknesses of timber laid close, in alternate right angled courses, and well bolted together into a solid block*, extending up to within a certain distance below extreme low water, to be hereafter decided. This timber to be thoroughly covered up with brush and rip-rap.

Should it be impracticable to use piles, other designs will of course have to be substituted.

It is a matter of considerable importance whether the spans of these bridges cannot be increased to advantage. The contingencies almost certain to arise in foundations of magnitude, are not met with in the superstructure, and a saving of one or two piers in deep water will certainly save time, and, perhaps, much money. This is a question simply of estimate, and should be very carefully examined.

I remain, Sir,

Faithfully yours,

(Signed,)

A. L. LIGHT.

N. B.—To obtain reliable information a proper set of boring tackle should be used, with the requisite piping, and other tools, to enable the bore to be carried through veins of quicksand, and drill through boulders, &c. Such implements are made a speciality of by Messrs. Spiller & Co., of London, England. Two sets were imported for use on the Intercolonial, for Miramichi and Ristigouche Districts. They are still in existence and doubtless can be easily procured. Without such tools and a person skilled in their use, it is impossible in some cases, to obtain that correct information, indispensable to the safe and economical foundings of works of magnitude.

APPENDIX NO. 10.

Quebec, December 29th, 1876.

A. L. LIGHT, Esq., C. E.,

Government Engineer.

DEAR SIR,

At your request I have compared the section of the St. Maurice River made from General Seymour's borings, with the section made from borings taken during the summer of 1876. And you will see after examining the following statement that they entirely disagree.

Pier No. 1 from east side.—Boring taken in 1876 indicates twenty-five feet blue clay over brown clay.

Seymour's borings show fourteen feet clay, sand or gravel, (the correct nature of material not defined) under which is called on the section a hard bottom.

Pier No. 2.—Borings taken in 1876, show eighteen inches of sand above strata of blue and brown clay of various thicknesses.

Seymour's borings show sixteen feet of sand, clay or gravel with hard bottom underneath.

Pier No. 3.—Borings of 1876, show five feet of gravel and six feet six inches of sand above blue clay.

Seymour's borings show a deposit of alluvium three feet thick and ten feet of clay, sand, or gravel over hard bottom.

Pier No. 4.—Boring of 1876, shows blue clay.

Seymour's boring show a deposit of alluvium over clay, sand or gravel, all above hard bottom. The above Seymour borings were taken on a line crossing the river one

hundred feet below the present located line. I changed the crossing in August, 1874, one hundred feet further up stream, therefore no borings have been taken on the present line previous to the summer of 1876.

I remain, dear Sir,

Yours truly,

(Signed,)

E. A. HOARE.

APPENDIX No. 11.

Three Rivers, P. Q., 12th August, 1876.

* * * * * Mr. Flanagan says he will undertake to put in a coffer dam with 4-inch plank for Pier No. 4, St. Maurice; but unless the masonry is carried above water this year, it would be lost labour, as the ice would destroy the dam. There is no stone delivered * * *

Yours, &c.,

JOHN EDW. BOYD.

APPENDIX No. 12.

ST. MAURICE BRIDGE.

St. Louis Hotel,

Quebec, 26th Nov., 1876.

ALEX. L. LIGHT, Esq.,

Government Engineer.

DEAR SIR,

We have examined your plans of the St. Maurice Bridge, including caissons and coffer-dams, and have no suggestions to make. We are quite sure that your plans can be carried out in this place without any difficulty. The bottomless caissons are more substantial than we have generally used, but in a strong current like the St. Maurice, they are the safe thing. We are trying to close a contract with Mr. McGreevy, but we cannot undertake the work to be completed by the 1st day of November, 1877, as required, unless we get a fair price; we ask nothing more. Should we close for the work, we will give bonds to complete it by the above mentioned time. To do this however, the work must be commenced at once. The bottomless caissons should be got in through the ice, and all dredging and pile driving done this winter. The stones also should be dressed and delivered on the ground for the masonry. We were sorry we did not see you, but Mr. Hoare explained the plans to us.

We remain, dear Sir,
Yours respectfully,

McFARLANE & McRAE.

Quebec, 18th December, 1876.

HONORABLE THOMAS MCGREEVY,

Contractor, &c., &c.

SIR,

On the 18th September, soon after receiving the correct borings from Mr. Odell, I moved the question of

the St. Maurice River foundations, with yourself and the Commissioners. I said I was then prepared with the necessary data to arrange the plans at any time you might desire. Your reply was to the effect that you proposed making a winter's job of this work, and there was no hurry for the plans. Since that date I have awaited your movement.

In again discussing the matter on the 5th inst. with the Commissioners and Messrs. Robert McGreevy and Odell, the latter gentlemen professed to think, the plan they sent in last spring had not been returned as disapproved; and therefore they had thought it unnecessary to take further action. This is a mistake. I have several times stated to Mr. Odell, (with whom the most of the business has been done,) my reasons for objecting to the plan submitted. Notably on the 23rd May, and again on the 29th in presence of Mr. Peter Grant. The plan in question was sent back from this office by order of the Commissioners on the 23rd of May, disapproved and has probably been overlooked.

As the ice will soon form in the St. Maurice, when pile driving, &c., can be done to advantage, at the request of your brother, I send a sketch of a pier and foundation I can accept. The St. Maurice being a more than ordinarily difficult river, I also offer you my views as to the best mode of getting in these foundations. This must be understood without prejudice, my object being the furtherance of the work, as if this bridge is to be completed, in a reasonable time, some mode *must* be devised that will admit of the foundations being prosecuted during the present winter.

If piles are driven here through the ice, and left unprotected, or uncut, they will certainly be carried away by ice and logs in spring. I have therefore arranged a plan for an outer dam or *bottomless caisson* to be sunk in advance, independent of the *water-tight caisson* in which the masonry will afterwards be built. This dam will act as a "water-deadner" to keep off the current, so indispensable in founding works of this kind, in a rapid river, like the St. Maurice, and will also afford the necessary protection against the spring freshets above referred to. I recommend

putting in these outside caissons at only three of the piers. Their cost I estimate about \$2,000 each exclusive of the stone filling.

The fourth or west pier I recommend being put in with a coffer dam. This dam should be built with not less than *two* rows of strong close piling, driven ten feet apart, to give stiffness to withstand spring freshets. The space filled between with puddled clay.

The water at this pier is but twelve feet deep, the bottom blue clay, sidling considerably transversely, which must be excavated to a level bearing—for these reasons a coffer-dam is the fittest mode of getting in this foundation. Should it be preferred the eastern pier being in but eighteen feet water, is also quite within the compass of a coffer-dam.

You might use either heavy wrought Iron caissons, or cylinders, or some mode that will allow of work being prosecuted through the greater part of the season: but the adoption of some such method will alone enable you to complete the bridge *permanently* in a reasonable time. The way I suggest I consider the simplest and best suited to position and climate.

I remain Sir,

Yours truly,

(Signed,)

A. L. LIGHT.

N. B.—These remarks will apply equally to the Ottawa River Bridge, which from the *number* of its deep-water foundations, is also a formidable work. I have added a short description of the mode of framing, sinking, and protecting, the bottomless caissons.

MODE OF SINKING BOTTOMLESS CAISSONS.

These caissons should be framed of 12'x12' square timber laid close, braced and bolted as shewn on plan. In piers one and two they may be built as shewn in drawing No. 1, with flat bottoms and sheet piling omitted.

In pier No. 3, numbering from the east there is some ten feet of sand to be removed, and this caisson (if built in winter when divers will not go down to remove timber and other obstructions, from under the cutting edges) should be as shewn in plan one, with sheet-piling driven around it, to prevent the sand from running under the bottom, while the dredging is being done. Should the work however be delayed until next summer, drawing No. 2, shewing cutting edges is to be preferred, as it makes a much better protection to the pier itself.

These cribs should be framed *on*, and sunk *through* the ice; a few guide piles being first driven as shewn. Loose stone being filled into the spaces between the skins of timber. After the crib has settled, sheet piling 12'x9' inches should be driven all round and bolted to upper side of caisson. The sand can then be removed with a clam shell dredge, after which the permanent piling for the foundation can be driven. These piles should be not less than fifty feet long and ten inches diameter at small end, for the two centre piers, and proportionately shorter for piers one and four. These piles can then be cut off at level of river bottom. All this work can be done in winter, the ice forming a platform to work from. The work now will be in a position to receive the "water-tight caissons," the lower halves of which, being framed in advance, on shore, can be launched as soon as the weather will permit, and floated inside of the bottomless caissons, and built up as required, the necessary masonry being put in to sink it in position.

The above process can be carried out in all the piers, except the one founded in the coffer-dam, which can be worked in the ordinary way.

To completely insure the outer caissons and coffer-dam from possible injury from ice or logs in spring, it will only be necessary to cover them cross-ways with heavy rough flooring and build on this say 500 tons of loose stone, this in addition to the filling between the timbers will enable them to resist nearly as much pressure as the finished piers.

The cost of stone used in filling and loading need not be seriously considered as it will furnish the material for the rip-rap required for the protection of the work. This

rip-rap protection has not been shewn in the accompanying sketch; it will be put entirely around the piers and in between, and over the caissons, after the upper portions of the latter have been removed.

(Signed,) A. L. LIGHT.

ST. MAURICE BRIDGE.

26th December, 1876.

HON. THOMAS MCGREEVY,

Contractor, &c.

DEAR SIR,

I herewith return the plan of iron cylinders lately submitted by you for the piers of St. Maurice Bridge. I do not approve of them, considering them unsuitable for position and climate.

I would once more bring under your notice, the general design for these piers, built with masonry on pile foundations sent to you on the 18th inst., as one I think peculiarly fitted for the situation.

As the matter is very urgent, I desire to see these works started as soon as possible.

I remain, Dear Sir,
Truly yours,

A. L. LIGHT.

Quebec, December 29th, 1876.

HON. H. G. MALHIOT,

Chief Commissioner Q. M. O. & O. Railway.

DEAR SIR,

In reply to Hon. Thomas McGreevy's letter of the 27th inst., just received, returning the unsigned plan of St. Maurice River bridge, I beg to say that the plan was pre-

pared for the information of the Commissioners, to illustrate the best and safest mode of working throughout the winter. It was sent to Mr. McGreevy at his brother's special request, by way of suggestion, as a design that I could accept. This will account for its being unsigned.

I here repeat what I wrote Mr. McGreevy on the 18th inst., viz: that I consider the design in question the best fitted for position and climate.

With regard to the time Mr. McGreevy says it will take to complete the work, if built on this design, I unhesitatingly say that in no other way can it be so quickly or so cheaply done, for a *permanent* structure. I say so advisedly, having had a large experience in such matters. Further, were the works let promptly to *first class sub-contractors, at fair prices*, there would be every likelihood of the bridge being completed next year—but these two points are essential to that end.

The contractor disputes my statement that the plan was returned to his engineer. Whether he received it or not is immaterial so long as he knew it was disapproved, of which there is no doubt. In May, I told his engineer that it was disapproved and requested him to remove it.

I further notified Mr. Odell, (as he admits in his letter of the 27th inst. to his employer,) that I would not approve of any plan until the proper borings were furnished, that had been asked for on the 14th February last, and begged him to use his influence to get them done. I also specially disapproved of the plan submitted. I am only surprised that Mr. Odell's memory should have failed him, regarding the several conversations held with him on the subject of the disapproval of the plan submitted by the contractor on the 8th May; some of which conversations were held in the presence of others.

The final borings were not sent in till the 4th September. After carefully considering the subject, I notified Mr. McGreevy on the 18th September, (as you are aware) that I was ready to discuss the nature of the foundations. I had previously told the Inspecting Engineer, that I considered a coffer-dam best suited for the western pier,

and asked him to report on it. He stated the contractor's employees declined to make the dam this autumn, as there was not a *single dimension stone on the ground*, and very little timber of a proper quality to build the pier, therefore the permanent work could not be begun this autumn, and the dam might be injured in the winter.

Instead of the new borings verifying as Mr. McGreevy states "in material points, the borings made in 1874, and on which my plans were based," they were entirely different vide Mr. Hoare's letter attached. Moreover the new borings were taken one hundred feet to the north of the old disclosing entirely different strata, the line having been changed in the interim.

The plan submitted in May, had it been adopted, would have certainly led to disaster in case of pier No. 3. No arrangements having been made to remove the twelve feet of sand and gravel found there. The design besides was considered insecure, and therefore disapproved.

The contractor's engineer foresees "great difficulty in sinking masonry in water-tight caissons." The mode I propose is the usual and only way, and I will guarantee there will be no difficulty. He also considers "the piling under the foundation unnecessary, as the water-tight caissons could be sunk any depth in the clay." This caisson has a rectangular base and flat bottom twenty-one feet by forty-seven feet; it will be sunk in water thirty feet deep, and it could not possibly be sunk in clay of itself, without large expense of extra dredging in advance, and would then be unsafe without the piles.

Since Mr. McGreevy gives up the idea of furnishing a plan for this work, I am prepared at once to approve, sign and transmit this design to him, and guarantee its practicability.

I remain, Dear Sir,

Yours faithfully,

(Signed,)

A. L. LIGHT.

HON. H. MALHIOT.

DEAR SIR,

Mr. Boyd reports that the contractor proposes sinking the masonry in the east pier of St. Maurice Bridge, without putting in either the bottomless caisson or cofferdam recommended to him in my letter of 18th December, copy of which was sent you. This is a hazardous proceeding. It might save a little in first cost, but on the other hand might delay the work. Should the river (as is only probable) break up before the masonry is above high water, the water-tight caisson would probably be broken also; and, if so, there is no way of repairing it, and a cofferdam will still have to be driven.

The contractor having disregarded my advice, I protest against being held responsible if delay occurs.

There is a difference of level of at least 4 feet in the bottom between the upper and lower ends of the Pier, the upstream end being lowest. The piling can only be cut off to the highest level, thus leaving the piles at the upstream end projecting four feet. The water is 19 feet deep at the lower end and 23 feet at the upper. It is proposed to fill the spaces between the pile heads with stones and level them with a rake. In such deep water this is an uncertain process. It will be difficult to tell when the stone is level with the pile heads. This can only be properly ascertained by a diver.

It will be safer and nearly as cheap to drive the cofferdam round the pier, as at first intended, and level the bottom (as done on the west pier) or else defer sinking masonry until the water gets warm enough for a diver to work.*

If the caisson be used, close piling must certainly be driven round the projecting portion of the foundation as a protection. This piling would form a dam and aid in sinking and protecting the water-tight caisson. It should first be filled with stone to the height of the pile heads. The dam piles, after the masonry is finished should be cut off ten feet above the bottom, and the whole finally buried in rip-rap to the top of footing courses, as shewn in sketch.

* If the caisson is already framed it can be used on one of the central piers.

To do this will cost \$5,149, or as much as the cofferdam. (See Estimates attached.) The latter would make a safer job and the masonry would be got out of water simultaneously with the western pier, instead of having to wait perhaps three months until the water falls.

Masonry is to be begun at the west pier immediately—it is a month too soon—cement laid during frost never sets properly and the masonry they are going to lay between the bottom and high water level requires to be very strong.

Doing work out of season will not really expedite matters, while the two central deep water piers remain untouched. These will take the longest time and should have been first begun—they are the keys of the work.

Setting masonry is not a lengthy matter when once the stone is dressed and delivered. Each pier can be worked separately, and by working two gangs eight hours each day, there would be little difficulty in laying twenty yards a day on each. There is about 800 yards in each pier; if simultaneously begun, the whole could be laid in less than two months. Working at improper seasons is therefore unnecessary.

What I recommended in my letter of 18th December, 1876, was to get in all cofferdams and bottomless caissons through the ice, excavate and dredge foundations, drive foundation piles and cut them off, frame water-tight caissons in advance, quarry, dress and deliver the stone. All this could have been done this winter, and there then would have been no difficulty in completing the bridge this year.

APPROXIMATE ESTIMATE FOR FOUNDATIONS—PIER NO. 1,
ST. MAURICE RIVER—FOUNDATION PUT IN WITH
CAISSON.

4320 lin. feet piling at 43c	\$1,849
1000 c. yards rip-rap at \$1.70	1,700
Water-tight caisson about	1,500
Diver	100
	<u>\$5,149</u>

[FOUNDATION PUT IN WITH COFFERDAM.

1600 lin. feet piling at 43c.....	\$ 688
47,000 feet sheet piling at 22c.....	1,034
81 c. yards excavation at \$1.....	81
90 c. yards extra masonry at \$14.....	1,260
1150 c. yards puddle at \$1.....	1,150
640 c. yards rip-rap at \$1.70.....	1,088
Pumping.....	800
	<u>\$6,101</u>

(Signed,)

A. L. LIGHT.

Quebec, 21st March, 1877.

ST. MAURICE BRIDGE.

Quebec, 2nd April, 1877

HON. H. G. MALHIOT,

President, Railway Commissioners.

DEAR SIR,

I have your's of the 30th ulto., on subject of rip-rap for pier No. 1, St. Maurice Bridge, wherein you say "it is very much to be regretted that orders were not given to put in the rip-rap before the caisson was allowed to be built."

I have already fully reported to you on this very subject, see letter 22nd ult., to which I beg to refer you.

The contractor has acted contrary to my advice in the matter, and I therefore most emphatically protest, against being held responsible for his mistakes. It is out of the question as I have already told you to attempt rip-rapping proper, without a diver, and the weather is too cold for one to work.

If the contractor intended putting in masonry at this very unseasonable period, he should have used a cofferdam, similar to the one that has been so successfully used

on the west pier, where he acted on my suggestion, or else he should have dredged the bottom to a level.

Caissons should not be sunk on piles at seasons when a diver cannot level up inequalities between the river bottom and the pile heads. Levelling up is particularly necessary in this case, as the piles can only be cut to the level of the highest point, the pile heads projecting some eight feet above the bottom at the lower point.

The contractor made borings and soundings for this work, and it was his business to have assured himself *positively* of the nature of the river bed before commencing work. The plan he submitted to me shewed a practically level bottom. Had I been aware of the real facts, and that he intended to work at an unseasonable period, I would have insisted upon a coffer-dam being used, by which means the bottom could have been excavated to a level, as was done at the west pier, where the plans submitted shewed a sidling bottom.

Mr. Boyd reported on the 22nd ult., that the contractor intended to sink masonry here in a caisson, without the outside protection I had recommended, also that the piles at upper end projected four feet above the bottom.

This was the first intimation I received either of the contractor's intention, or of the bottom being out of level. Mr. Boyd informed me that he had himself ordered rip-rap to be put between the pile heads.

I immediately communicated to you, and Mr. Chinic, my opinion, that the contractor ran a great risk of having his caisson destroyed by the breaking up of the ice.

Since you went away a report was received on the 28th ulto., informing me, that the difference of level amounts to eight feet in some places, and that in putting in rip-rap, there is danger of its interfering with the proper sinking of the caisson.

Any experienced contractor would have foreseen this difficulty.

Now to suggest a remedy. If the caisson can be safely moved half its length down stream, I recommend that

partial rip-rapping be promptly done, care being taken to keep the stones a safe distance, say eighteen inches below the pile heads, using small stones for the upper courses. If the caisson cannot be safely moved to admit the rip-rap, then the next best thing is to have the protection piling shewn on the sketch, put in about six feet from the caisson and cut off to the proper level, and a large quantity of rip-rap piled around the outside of the pier bottom, before the masonry is carried much above the water-level.

You will of course remember that in a letter to you of 29th Decem^{ber}, replying to Mr. McGreevy on the subject of St. Maurice Bridge, I particularly recommended that the work should be let (at a fair price) to some *thoroughly experienced* sub-contractor, and I mentioned Mr. MacFarlane to you, formerly of the International Bridge, who has so successfully put in all the difficult foundations, including the "Gatineau," on the western division, of this railway. He would have done the work *well* at a fair price, and guaranteed its completion within the year. Had Mr. McGreevy chosen to employ MacFarlane, no trouble of the present nature could have occurred. Instead of this, the contractor has put this important work into the hands of his brother, probably the most troublesome and least efficient man he could have found, who, so far appears to have done everything wrong, and this in the long run, will be found far the most expensive.

He has made a glaring blunder, so far as finishing the bridge this year is concerned, in leaving untouched, this winter, the foundations of the two deep water piers, which are the *keys* of the work, and any masonry laid at this unseasonable period on the two minor piers, near the shore, cannot materially advance the work, so long as the central piers, remain untouched.

I remain, Dear Sir,

Your obedient Servant,

A. L. LIGHT.

APPENDIX No. 13.

MR. HAMLIN'S REPORT ON 2ND DIVISION.

The masonry on this division is in a very backward state, chiefly owing to a want of energy to push it ahead during the proper season. However, I understand that strenuous efforts will be made this winter to deliver all the stone necessary for the different structures—1551 first-class bridge masonry, and 209 cubic yards of second class culvert masonry (laid dry) has been built this season up to the first December. There is still remaining to be built approximately 8560 cubic yards of first-class bridge and culvert masonry and 3528 cubic yards of second class culvert masonry. This estimate does not include the St. Maurice Bridge.

* * * * *

I am, Sir,

Your obedient Servant,

L. B. HAMLIN.

Three Rivers, P. Q., 13th December, 1876.

Three Rivers, P. Q., 2nd January, 1877.

* * * * * With regard to the timber at the St. Maurice crossing, I have not been able to see it myself, but Mr. Hamlin had a careful survey and classification of it made at the end of November, and a return sent to your office.

No.	Length.	The number of sticks fit for piles in the foundations of the two centre piers are given in the margin. A great deal of the timber is fit only for the outside caissons, and some of it not even for them.
1	56	
1	54	
19	52	
19	51	
18	50	
58 pieces		
==		

One contractor is quarrying stone on the piles branch for the St. Maurice Bridge * * * * *
 It would be for the advantage of both the Government and the contractor to have a good inspector sent to the quarry * * * as stone delivered badly dressed and shaped is apt to be worked into the masonry, and the proper place to inspect stone is at the quarry.

I have, &c.,

JOHN. EWD. BOYD.

Quebec, April 20th, 1877.

A. L. LIGHT, Esq., C. E.,

Government Engineer.

DEAR SIR,

At your request, I have prepared the following statement, of stone quarried and delivered between Quebec and Maskinongé; also, tabulated statement of finished and unfinished masonry between the same points.

The returns stand thus:

ESTIMATE TO 30TH NOVEMBER, 1876.

—	Cut Stone Delivered.	Cut Stone in Quarry.	Uncut Stone. Delivered.	Uncut Stone in Quarry.
Division No. 1.....	50 c. yds.	10 c. yds.	130 c. yds.	343 c. yds.
" " 2.....	255 " "		*797 " "	
Totals.....	305 " "	10 " "	927 " "	343 " "

* 200 cubic yards of this is very small, unfit for 2nd class masonry, nothing stated about stone in quarry on division 2.

ESTIMATE TO 31ST MARCH, 1877.

	Cut Stone Delivered.	Cut Stone in Quarry.	Uncut Stone Delivered.	Uncut Stone in Quarry.
Division No. 1.....	262 c. yds.	512 c. yds.	219 c. yds.	419 c. yds.
" " 2.....	1324 " "	1110 " "	2008 " "	1158 " "
Totals.....	1586 " "	1622 " "	2227 " "	1577 " "

STATEMENT OF FINISHED AND UNFINISHED MASONRY
UP TO 1ST DECEMBER, 1876.

	First-class Masonry		Second-class Masonry.	
	No. cubic yards done.	No. cubic yards to be done.	No. cubic yards done.	No. cubic yards to be done.
Division No. 1.....	8656	2300	3540	1427
" " 2.....	1551	12185	209	4428
Totals.....	10207	14785	3758	5855

The above Statements are compiled from the Division Engineer's returns, and ~~do not~~ include St. Maurice Bridge = 4,500 c. yards.

I remain, Dear Sir,

Yours truly,

E. A. HOARE.

See erratum

APPENDIX No. 14.

PORTNEUF BRIDGE.

Quebec, 13th May, 1876.

HON. H. G. MALHIOT,

Chief Com. Q. M. O. Railway.

DEAR SIR,

I have just been notified by the contractor's Engineer, that work is about being resumed upon the Portneuf Piers. I have already informed you that for certain reasons then explained, I had no confidence in the foundations of these piers. Three months ago I requested Mr. Robert McGreevy to have borings taken both at these piers and at St. Maurice River, to enable me to judge correctly and *safely* of what should be done at these very critical points. These borings have not yet been taken, and I am therefore quite unable to guarantee the safety of these high piers. No works of such magnitude should be begun upon foundations at all doubtful. Moreover, should iron superstructure be substituted for wood at Portneuf, it is altogether desirable that the sites of these piers should be moved further apart, so as to make the spans equal, which at present they are not.

Under these circumstances, I would suggest that the contractor be requested to suspend operations upon these piers until the iron bridge question is settled.

I remain, Dear Sir,

Very truly yours,

(Signed,)

A. L. LIGHT.

Quebec, 9th June, 1876.

HON. H. G. MALHIOT,

Chief Commissioner Q. M. O. & O. Railway.

DEAR SIR,

I have made a careful examination of the piers at Portneuf, where the foundations have been already put in, and a small portion of masonry built.

I have not confidence in these foundations, the masonry moreover, especially the portion laid last autumn *without inspection*, is of a very indifferent description entirely unfit for such important work.

I recommend that these piers be taken down, the foundations placed beyond a doubt, and the masonry rebuilt according to specification.

I remain, Dear Sir,

Faithfully yours,

(Signed,) A. L. LIGHT.

Three Rivers, 17th June, 1876.

A. L. LIGHT, Esq., C. E.,

&c., &c., &c.

SIR,

* * * * * I made a thorough examination of the masonry in the Portneuf piers, and find in the eastern pier the following defects:

In the top course, the face work has been laid without any hearting, instead of carrying both up together. Out of 15 joints in the top course, only three are squared back, the specified nine inches. In the face there are several places where the bond is under ten inches.

The joints are in some cases as much as one inch, and in many half an inch, and instead of being well flushed



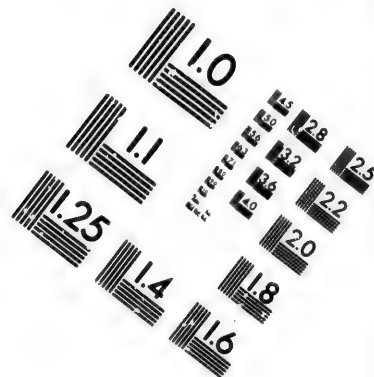
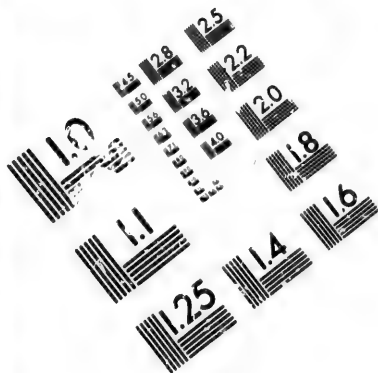
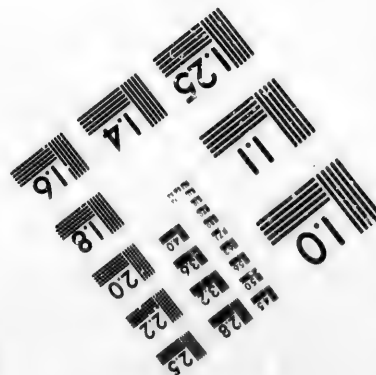
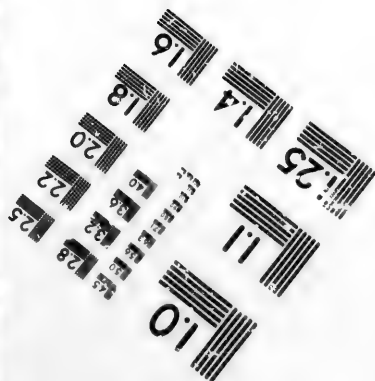
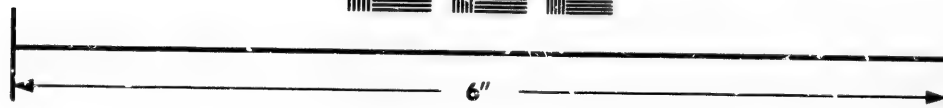
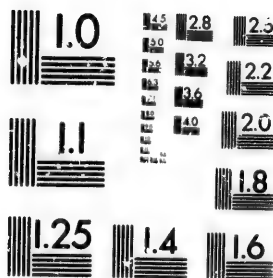


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full of mortar, are so open that I could put my rule six and eight inches into them.

The stones are not dressed flat and parallel on the beds. One stretcher especially, is up nearly an inch higher in the centre than at the ends.

It is perhaps unnecessary to say that one stone like that might and probably would crack the pier from top to bottom, especially as the joint is not well filled with cement, even of the inferior quality used. If the work that can be seen is so bad, it is hardly probable that the work in the foundations, which is covered from view is any better.

The work in the western pier is better in the face, but there is the same fault in the joints not being squared back far enough, only three out of the nineteen in. top course being right.

The deficiency in the proportion of bed to rise is common to both, and indeed to all the masonry, I have seen on the line whenever the height of course exceeds sixteen or eighteen inches, to which the specification should have limited them.

I have no hesitation in saying (especially in respect to the eastern pier,) that it would be unsafe to build so high a pier on such masonry as that now laid. * * * *

I have the honor to be,

Sir,

Your obedient Servant,

(Signed,) JOHN EDWARD BOYD.

Three Rivers, July 24, 1876.

SIR,

* * * * * The eastern abutment pit at Portneuf, is quite as bad as I expected. The material, blue clay and sand, full of water which runs to "slurry" after a short exposure to the air. They are still digging at it.

The eastern pier is being taken down.

I presume before the new masonry is begun, you will order the bottom to be bored. This work is still suspended for want of stone; a temporary track is being laid to Deschambault quarry to bring it down. The quarrying is going on very slowly.

There were only about fifteen men at work on Friday, and I am told that this is about the average.

The stone is of good quality, but comes out in bad shapes, so that the proportion which can be worked into face stone is smaller than usual. There is a lot of very good backing however.

Stears says he thinks it will be a month before they have enough stone delivered to make it worth while to begin building.

Would it not be well to order (under section 14) that the backing of these piers should be in one thickness to each course. * * * * *

(Signed,)

JOHN E. BOYD,

A. L. LIGHT, Esq., C. E.

Three Rivers, P. Q., 3rd June, 1876.

SIR,

I beg to submit a report on the state of the bridge works at the close of the month of May.

At the Jacques Cartier River the pier is being taken down. The work in this pier is not up to any specification for first-class masonry that I ever saw. Many of the stones "tail off" very much, leaving only from 3 to 6 inches of a square joint, and some of them are slack in the beds. I pointed out these defects to Mr. Gauthier, the *present* inspector. He seems to know what is required to make good work, and promises to insist on its performance * * *

I have, &c.,

JOHN EDW. BOYD.

Quebec, July 25th, 1876.

ROBT. MCGREEVY, Esq.

SIR,

I am in receipt of a letter from your Chief Engineer dated the 24th instant, stating that the east abutment and Pier at Portneuf will be ready for inspection on Monday next. I inspected them personally a few days since, and will have them inspected again on Monday, as you desire.

Before any decision as to the foundation can be safely arrived at, borings must be taken at both places, as I wrote you last February. Should these borings shew that the stratum of blue clay shewn by the present excavation continues downwards, it will be necessary to carry a crib surrounded by piling and filled with stone, down, probably, to the level of the stream bed. Piling, at any rate, will be required unless rock or hard pan be found.

I agree with Mr. Odell "that it is of the utmost importance that this matter should be attended to at once in order to secure, if possible, the completion of the structure this season." It is moreover of great importance to you that it should be done promptly. Should the work not be completed before the autumn rains set in, the whole will slip in again, unless a large expenditure is incurred in shoring up the sides of the excavation. It is impossible to foretell with such material where such slips may stop, as has been found at Trois Pistoles, where the same treacherous material was met with. Should this occur, the unfinished masonry even may be swept away.

As the matter is so important and requires prompt action I would suggest that ordinary tackle such as can be quickly improvised anywhere, will suffice to bore through the blue clay at the site of the abutment where contingencies are not liable to arise—not so, however, at the Piers. Here boulders may be anticipated that *must* be drilled through, requiring elaborate machinery, and as the Portneuf Bridge is the key of the position, I advise the tools from the St. Maurice being brought back for a day or two to complete these borings.

I hope you will succeed in completing this work this autumn; otherwise all work west must be delayed thereby.

The division engineer, however, reports that the temporary track to the Deschambault quarries, from which, I understand, you propose getting the bulk of the stone is still incomplete. While the sub-contractor for the masonry states there is so little dimension stone now on the ground that he objects to resume the work that was stopped (nearly a month since on 1st July), until sufficient stone arrives to carry it on regularly. The time returns also shew that there are but 15 men in the quarry; there should be 100 to give the necessary supply of stone to complete the masonry this autumn.

Had steps been taken to deliver the necessary stone last winter (which could easily have been done), and borings taken in time (as requested) to define the foundations, there would have been no difficulty in completing this important work this season.

I remain, Sir,

Yours truly,

(Signed,)

A. L. LIGHT.

APPENDIX No. 15.

27th January, 1877.

JOSEPH TOMLINSON, Esq., C. E.,

Board of Works, Ottawa.

DEAR SIR,

Herewith I enclose a section of the valley of the River Portneuf, shewing an arrangement of proposed foundations there—also, a plan and elevation of the mode upon which I propose to put in the Eastern abutment.

As there is a difference of opinion between myself and the contractor, respecting the proper mode of treating this foundation, I am desirous to have an independent opinion from another engineer of great experience in such matters, that all parties will respect—I therefore refer the matter to you, oblige me by giving it your early attention.

The view shewn on the section of the river crossing giving an elevation of the whole structure, is the mode proposed by the Contractor's Engineer, viz.: to lay a platform of timber and concrete, and build the masonry on it. The objection to this is, that the whole may slip forward bodily. To avert this, I propose to pile under this platform, in the mode shewn in the accompanying sketch. Piles 25 feet long, being driven 6 feet apart, and waled and cross-waled, with 3 feet of concrete between and over their upper surfaces, to bond the whole and keep out the water. The piles, towards the front of the abutment, have a rake backwards of 12 inches in 12 feet, and the platform itself projects eight feet in front of the face of the abutment to render it more difficult to tip it forward, part of the pressure coming from behind.

I can understand that, before giving an opinion upon such an important question, you would like to see the ground. This being impracticable, it will be sufficient to rest assured, that it is as bad a place as can be imagined. The clay is so slippery, that the portion cast out of the foundation has run into the stream below, much of it being piled against the first pier to the height of

ten feet. The contractor's argument against piling is that they will have a tendency to break off the whole front of the excavation. My reply is, that if the ground will not bear piling, it will not stand without them, and some different design from either must be adopted.

Please give this matter your careful consideration, and send me your full reasons, so that I may lay them before the Commissioners; at the same time send your charge.

I remain, Sir,
Your obedient Servant,

(Signed,) A. L. LIGHT.

Ottawa, February 1, 1877.

A. L. LIGHT, Esq.,

Chief Engineer Q. M. O. & O. Railway.

SIR,

I beg to acknowledge the receipt of your letter of the 27th January, requesting my professional opinion on the proposed foundation for the eastern abutment of the Portneuf bridge, also enclosing for my information tracings showing a section of the valley of the river, result of borings under the foundation pit, and the proposed arrangement of piles united with waling pieces and concrete, with the position of the abutment thereon.

I would first remark that clay, notwithstanding its apparent stability, is probably the least reliable material that heavy structures can be founded upon. This is particularly the case under bridge abutments, which in addition to their own weight and that of their heavy superstructures generally act as retaining walls for high embankments. The combined weights of the masonry, superstructure and embankment tend to force the face of the abutment forward on the gradually yielding nature of most clays and allow it to settle. The surface stratum of clay in your case, being of so viscous a nature when moist, makes it in my judgment not only an advisable precaution, but absolutely necessary, to pile the foundation pit as you propose. The two strata of sand, as long as protected by the clay and un-

disturbed by running water are thoroughly unyielding and the intermediate stratum of clay under the great and uniform pressure to which it is subjected will be much firmer than the upper one. The use of piles will transfer the greater part of the weight from the upper stratum to these three lower strata. Piles have a tendency to consolidate clay as is frequently shown by its swelling around them while being driven, any idea that clay will split by driving piles, and admit moisture to produce a slide must be imaginary. The manner in which you propose to unite the heads of the piles, after they are driven by bolting double waling pieces to them in each direction will be very effective in confining the concrete and in distributing the weight uniformly, so that there will be no probability of perceptible settlement. And I doubt if any other arrangement equally efficient could be made at the same expense; I should consider it better to have a greater number of rows of piles from back to front, say twelve in the place of the nine proposed. Driving the pile with a rake backwards, will enable them more effectively to resist the forces bearing against them, consequently I would deem it desirable to drive more of them at the same inclination.

Considering the unreliable nature of the surface clay and the decided advantages of connecting the foundation with the two strata of incompressible sand that are at such suitable distances from the bottom of the pit, I would if I were a contractor who had to be responsible for the permanency of the work, prefer to incur the additional expense of driving the piles, as in that case I would feel confident that no movement could take place in the masonry of the abutment as the strata of sand are fully secured by the superincumbent clay against any disturbance by water.

Taking all the facts into consideration, I have no hesitation in stating that if the plan you propose is faithfully executed, the foundation will be of the most permanent and substantial description, and will give perfect satisfaction both to the Board of Commissioners and the Contractor.

I have the honor to remain,

Sir,

Your obedient Servant,

(Signed,) JOS. TOMLINSON.

APPENDIX No. 16.

MASONRY.

Quebec, 19th June, 1876.

HONBLE. H. G. MALHIOT,

Chief Commissioner, Q. M. O. & O. Railway.

DEAR SIR,

As the culverts and small bridges between here and Three Rivers are about being begun in several places, I would draw attention to the fact that the masonry of which these structures have hitherto been composed is of very inferior description, unfit for the requirements of a first class railway.

I therefore recommend that the class of masonry now in use on the Western Division of the Q. M. O. & O. Railway, be adopted on the Eastern Division also.

This most necessary improvement is covered, it is considered, by the following paragraph in the report of Messrs. Baillaigé and Light, of the 13th March, 1875 :

" Mr. Light being of opinion that the specifications for " masonry on the M. N. and Colonization Railway, owing to " their freedom from ambiguity, be adopted on the North " Shore Railway."

I remain, Dear Sir,

Faithfully yours,

(Signed,)

A. L. LIGHT.

APPENDIX No. 17.

MASONRY.

Pont Rouge, 7th August, 1876.

DEAR SIR,

* * * * * The dry masonry in box culverts is not up to specification, that is the last specification which was issued.

In so far that in many instances pinnars have been used and the top stones of walls are not all through stones. .

As to half-inch joints, it is simply impossible to get them in this class of masonry.

Some of the sub-contractors building this dry work, I am informed, have only \$4 per yard for it, furnishing and cutting stone included. Under these circumstances it is quite impossible for them to build up to specification, so that they must either abandon the work, or do it in defiance of inspectors. Before closing this, I beg to protest against being held responsible for any work which is being done between Bell's Road and the City of Quebec. This has entirely been engineered by one Rask, in Mr. McGreevy's employ and pay, who has never reported to me, nor have I been notified of his appointment. He has designed and laid out the culverts and grading without any consultation with me; and I found, on passing over the line, that the class of dry masonry being built on that part is so bad that it is not even worthy of the name of masonry, nor would it be admitted in an ordinary public highway.

* * * * *

(Signed,)

JOHN LINDSAY.

APPENDIX No. 18.

INCREASE OF MASONRY CAUSED BY CHANGES OF GRADE BETWEEN QUEBEC AND THREE RIVERS.

July 10th, 1876.

Jacques Cartier Bridge.....	58	cub. yards.
Portneuf Bridge.....	54	" "
Culvert at 1463—7 x 6.....	32	" "

Total 1st class..... 144

Sections 13 to 17—13 culverts.....	80	cub. yards.
" 19 corbel box 1 culvert.....	25	" "
" 31 to 33 6 "	28	" "
" 33 to 40 6 "	30	" "

166

1st class masonry, 144 yds. at \$14.....	\$2,016
2nd " " 166 " " \$7.....	1,162

\$3,178

(Signed,)

JOHN LINDSAY

APPENDIX No. 19.

MASONRY.

Quebec, 11th August, 1876.

HON. H. G. MALHIOT,

Chief Commissioner, Q. M. O. & O. Railway.

DEAR SIR,

Messrs. Boyd and Lindsay report that they have condemned 476 yards of culverts, built in July, as not in accordance with the specifications for second-class masonry, of the Montreal Northern Colonization Railway, much of it not even as good as that required by a rigid reading of the old specification.

The former class was recommended in my letter of 19th June to the Board, who, after the most careful consideration as to the propriety and *legality* of the change, adopted it on the 20th of June.

Their decision was immediately communicated to the contractor's engineer, who at once notified his employer. This was long before any of this masonry had been begun.

The reason given by the Division Engineer for so much inferior work having been allowed without an earlier protest, is that at first the orders of the Inspectors were attended to—as evidenced by upwards of 600 yards of culvert masonry being returned in the July estimate. Subsequently, however, Mr. R. McGreevy passed over the line, and peremptorily forbade sub-contractors to carry out inspectors' orders in this particular.

The sub-contractors when spoken to about the quality of work complain that their agreement with Mr. McGreevy was to build an entirely different class of work from that which the specification requires, and that their prices are too low to build such work, some of them getting only \$4.00 per yard, while Mr. McGreevy's price is \$7.00.

The defects of the condemned masonry are that the stones are often much too small and not dressed on beds and builds, the deficiencies being made up by spalls or pinners, instead of being thoroughly dressed down to half-inch joints as required by the specification. The backing is comparatively worthless and the bond imperfect. On this last head, the specifications read: Clause No. 18, "Every attention must be paid to procure a *perfect bond*." To attain this, among other things, a six inch joint, and an eight inch lap was ordered—similar to what was used under the same circumstances on the Intercolonial (built on same specification). Nine and ten inch joints, as used in first-class work, might have been required under the specification, but the smaller sizes were deemed sufficient. These even were countermanded.

Most of these structures are covered with but two to three feet of embankment, and it is almost unnecessary to say that such imperfect masonry is not fitted to withstand *long* the violent shocks and vibrations caused by heavy engines running at high velocities, and should therefore be taken down and rebuilt in accordance with the specification approved by the Board.

This opposition to the well understood orders of the Commissioners is most unwarrantable and should be effectually dealt with—nothing short of promptly pulling down the work will meet the case.

The cost of taking down and rebuilding properly will amount to about \$3 per yard, say \$1,500 in all. If not insisted upon, the Inspectors may as well be dismissed; their orders having been defied, they will have little future weight.

A good deal of the stone contiguous to the line of which the masonry must be made is subject to "drys and flaws" and not to be depended upon, when laid without mortar, above a certain height. I therefore recommend that the second clause of the Seymour specification—forming an important part of the present contract—be insisted upon, and that all masonry above five feet in height, be first-class and laid in Portland cement. This clause thus reads: "Bridge abutments and piers, arch culverts, and the side walls of open drains, road crossings or cattle passes, ex-

"ceeding five feet in height will be laid in hydraulic mortar, and will correspond in character to what is generally termed first-class rubble masonry." In circular No. 2 likewise part of the contract—this first-class rubble is defined as "intended to be fully up to the standard for similar structures on the Intercolonial, Grand Trunk, Great Western or any other first-class railway in Canada."

All first-class masonry erected by the present contractor, previous to this season, has been built under the original Seymour specification supplemented by explanatory circular No. 2, under which combination good *first-class* work can be had.

The Seymour specification for second-class was vague and the little masonry previously built under it very bad. For these reasons, and finally to close future disputes, Messrs. Baillairgé and Light recommended that the M. N. C. Railway specifications, from their freedom from ambiguity, be adopted." In arranging the new contract, seventy-five per cent was added to the Seymour price to cover the cost of improved work on second-class masonry.

In 5th clause of Seymour specification, it is stated "that the mortar used in masonry must be composed of the *best quality* of hydraulic cement, &c." The best quality is undoubtedly Portland. Careful experiments conducted by myself on a comprehensive scale at the Miramichi Bridges, and made with the cement testing apparatus of the (London) Metropolitan Board of Works, conclusively proved Portland cement to have from three to four times the tensile strength of either Quebec or Hull cements; much more reliable and uniform in character, and from its carrying more sand, but little more expensive in the end.

For above reasons I recommend Portland cement for all structures where mortar is required *under* the track—safety being the first desideratum.

I remain,

Faithfully yours,

(Signed,)

A. L. LIGHT.

APPENDIX No. 20.

MASONRY.

7 *Rivers, P. Q., 12th August, 1876.*

A. L. LIGHT, Esq., C. E.,

&c., &c., &c.

SIR,

* * * * * I hope you were able to run out and look at the culvert I reported by telegram (station 145). The face is of small stones wedged up with pinners, and the backing is simply stone, such as would be used for macadamising, shovelled in to all appearances. Judging from this, I fear that deceived by the face, I spoke too favourably of the other work done by this man Mackay, in saying "it was fair, strong, *third-class* work."

Matters have reached a point, where if you do not insist on his dismissal from the work, for persistent disobedience of orders, our authority becomes a shadow. * * * * * Since I saw the culvert at station 145, I am convinced that every box culvert built by him should come down. * * * * *

(Signed,)

JOHN ED. BOYD.

APPENDIX No. 21.

MASONRY.

Quebec, 15th August, 1876.

ROBERT MCGREEVY, Esq.

SIR,

Referring to our conversation of yesterday, in the course of which I desired you to dismiss McKay, on account of the bad work he was making on the culvert masonry, and from his persistent refusal to attend to orders, literally setting the staff at defiance, I would remark that I visited the works near Bell's Road yesterday, with your Engineer, and found matters but little improved. The work there is not near as good as would be obtained under the old specification; therefore it is nonsense for him to say that he is working strictly to your specification, unless you have given him something different from either. The clause referring to the top stones bonding the entire wall is ignored, and is essential, and will be insisted upon under any circumstances. The backing generally is composed of stones, that might have been put in with a wheel barrow, to the extent of a considerable portion of the masonry. The clauses about bond, joints, sizes, &c., are generally neglected, and the whole, results in bad work. I feel assured that if you knew how bad the work really is, you would be the first to dismiss McKay. Proceeding from Bell's Road West, as far as we went, we found most of the work indifferent, all done, I believe, by the same man.

I need hardly say that such masonry cannot be accepted, and taking it down hereafter will cause serious delays.

Returning towards town with your engineer, for the purpose of fixing the sizes of the structures on the new work, we were both surprised to find many already in place. Referring to Mr. Lindsay, he informed me he has never

even been consulted about them. He has not set them out, nor have they been inspected by his inspectors, and he says "that one Rask, having no connection with this staff, has been employed to do this work." This, of course, is an irregularity that you must take the consequence of.

Much of the stone delivered along this portion of the line is small, and unfit for the work. It can only be used by getting a quantity of new stone of large dimension, for the purpose of bonders and laying the whole most carefully with Portland cement.

I remain,

Faithfully yours,

(Signed,)

A. L. LIGHT.

APPENDIX No. 22.

**REPORT ON MASONRY OF CULVERTS ON NORTH SHORE
RAILWAY, FROM CITY OF QUEBEC, WESTWARD.***4th September, 1876.*

To A. L. LIGHT, Esq.,

Government Engineer.

SIR,

In compliance with your request, I last week minutely examined as far as practicable, the undermentioned structures, of which I beg to report as follows :

No. 1 Box Culvert 3 x 3—Stones in face work large, and, as far as I could judge, well bedded and bonded.

Coping not dressed as shewn in plan ; paving not well laid ; stones inferior ; water runs under paving.

The only way to cure this is to take up end walls and carry them across opening to level of top of paving—end walls shew 3 feet deep.

No. 2 Box Culvert 3 x 3—Masons employed finishing side walls and laying covers ; walls built with Portland cement ; work apparently strong and substantial ; pavement roughly laid and not cemented ; all pavements of culverts ought to be well paved and thoroughly grouted with hydraulic cement.

No. 3 Box Culvert 4 x 4—Stones in face large ; workmanship fair, except some spauling in face work ; cannot, of course, tell how interior of work is built ; coping not as shewn in plan. This culvert is dry masonry.

No. 4 Box Culvert 3 x 3—Dry masonry, very poorly built ; many spauls in face work ; paving and coping badly laid, and stones unsuitable.

No. 5 Box Culvert 3 x 3—Dry masonry; about the same as No. 4; great deviation from plans and specifications, and coping and covers not near up to the mark.

No. 6, 6-feet Beam Culvert—No attempt in many instances to dress vertical joints; some unsound stones in face work; some spauls in front work; bond not good; pavement and coping inferior.

No. 7, 6-feet Beam Culvert—Some improvement on No. 6, but there being 2 feet of water in bottom, could not ascertain quality of work; some unsound stones in face, and large joints; coping not according to plan in this or any of the structures.

No. 8, 9-feet Beam Culvert—An improvement on lesser beam culverts, but on account of water in bottom, can say nothing of lower course or pavement; no part of work first class.

No. 9 Box Culvert 3 x 3—Dry masonry; great many spauls in face work; not anywhere up to specifications or plans.

No. 10 Box Culvert 3 x 3—Dry masonry, about same as No. 9; no coping on this or any other of the structures up to plan.

No. 11 6-feet Beam Culvert—Stones in this structure large, but most roughly built; coping inferior, and paving badly laid.

No. 12 Box Culvert 3 x 3—Dry masonry; stones large and well bonded, but several spauls in face work; lower end requires to be paved; coping inferior.

No. 13 Box Culvert 4 x 5—This structure seems strong and composed of large stones in face and wing walls; several spauls, however, in face of walls; bottom composed of soft shell rock; not paved; ought to be done, or foundation will soon be undermined; dry masonry.

No. 14 Box Culvert 3 x 4—This culvert composed of large stones; apparently well bedded; some spauls in face of

masonry ; requires to be paved ; bottom of soft shell rock dry masonry.

No. 15 Box Culvert 4 x 6—Laid in cement ; masonry composed of large granite blocks ; no spauls in face work ; side walls, which are within 1 foot of height, now in progress.

No. 16 Box Culvert 3 x 3—Dry masonry ; very roughly built ; any quantity of spauls in face work ; coping and covers badly laid and too small.

No. 17 Box Culvert 3 x 3—Dry masonry ; some better than No. 16 ; still very inferior.

This was as far as my inspection proceeded, and in viewing the work from a stand point of Intercolonial Railway experience, I consider second-class work on that railway, far superior to any masonry I have yet inspected ; notwithstanding both works are based on nearly same plans and specifications.

I would respectfully recommend that all culverts over three feet in width be corbeled to that width, as a greater security to covers. More attention must also be paid to pointing covers, which so far has not been done.

The pavement of culverts has been very inefficiently done throughout.

I would recommend all culverts to be well paved and thoroughly grouted.

There is not a single piece of coping on any culvert, as shewn in plan.

I would emphatically protest against the plan so universally adopted here of inserting spauls in face work of masonry, as the principle once conceded, such innovations have a tendency to get worse and worse, and it is a matter of surprise to me that any inspector allowed such deviations from specifications as is to be seen in all parts of the masonry.

I fear, however, efficient men will not easily be found to assume the responsibility and anxiety connected with the faithful discharge of their duty on this important work, at a monthly salary less than the foreman of a paltry culvert.

(Signed,)

JAMES SUTHERLAND.

POSTSCRIPT TO MR. SUTHERLAND'S REPORT OF 15TH
SEPTEMBER, 1876.

* * * * * On re-considering the recommendation to lay cut stones partially in cement mortar, I have since come to the conclusion that all structures built of granite should be built throughout with hydraulic cement; as being more conducive to strength of work, and also facility in building. As from the rough and unshapely blocks of rubble granite, it is next to impossible in backing up the cut stones to secure strength without the whole being well bedded in mortar.

(Signed,)

J. S.

APPENDIX No. 23.

MASONRY.

Three Rivers, P. Q., 22nd Sept., 1876.

ALEX. L. LIGHT, Esq., C. E.,

Chief Engineer, Gov. Rys., Quebec.

SIR,

* * * * *

I have seen a copy of Sutherland's report and think it necessary to draw your attention to some points in it.

1st. The beam culverts on which he reports unfavorably, but which I passed, were not intended to be first-class masonry, as they were built before the "5 feet high" order was issued, and before the cement question had been finally settled.

2nd. His report on the box culverts does not differ materially from mine, but the culverts passed by me in June, were built before the present specification was issued. No paving was returned as if in, at all, it was badly done. For the July estimate, I condemned, under the *new* specification, every box culvert built that month.

3rd. I do not see any necessity for grouting pavement, if it is set on edge and well rammed as it should be, and the end walls built across below the openings. I confess that it is difficult to get proper attention paid to the paving, and grouting might be made a penalty, for not putting it in as ordered.

4th. His expression that he must "protest against the plan so universally adopted here of inserting spalls in the face of masonry" would lead a stranger to suppose we had permitted this, whereas I know the inspectors did their best to prevent it. I have condemned culverts otherwise passa-

ble, because there were pinners in the face-work, and I never heard even a sub-contractor attempt to justify the practice.

If Sutherland's report had been a confidential one to you, I should not presume to remark on it, as you are aware that men of his class do not always see the force of their own expressions, but as the report appears to have been seen by Lourie and others, I trust you will forgive my calling your attention to such parts of it, as may seem to outsiders to reflect on the staff generally, and me in particular. * *

I have, &c.,

JOHN EDW. BOYD.

APPENDIX No. 24.

MEMO. sent the undermentioned Bridge Builders to obtain prices by which the Width of Spans of the different Bridges could be most economically arranged.

Clarke, Reeves & Co.,	Philadelphia, Pa.
Keystone Bridge Co.,	Pittsburgh, "
American "	Chicago, Ill.
Watson "	Paterson, N. J.
Niagara "	Buffalo, N. Y.

GENTLEMEN,

Please advise me your lowest *cash* rates for wrought iron single track through, and also deck railway bridges, delivered at the port of Quebec, and including custom duties of $17\frac{1}{2}$ per cent *ad valorem* of the following spans:

Clear spans	230 feet.....	125 feet.
	200 "	100 "
	175 "	75 "
	160 "	50 "
	150 "	

Pivot draws—2 openings of 100 feet each, 230 over all.
" " 2 " 50 130 " "

All bridges to be first-class in every respect and conform strictly to the following specification. Strain sheets must be submitted before any tender will be accepted.

LOAD.—Two locomotives weighing with tenders not less than 60 tons each, and throwing 30 tons on drivers within 12 feet. Rest of bridge 2,000 lbs. per foot.

STRAINS.—Tensile 10,000 lbs per inch. Shearing 7,500, compression to be determined by Gordon's formula with factor of five.

QUALITY OF IRON.—Iron used in compression and under transverse loads to be of proper hardness and toughness. Iron used in tension to be *double rolled* and of an ultimate strength of 55,000 to 60,000 lbs. per square inch. No permanent set under 30,000 pounds per square inch, and of such toughness that a flat bar $\frac{3}{4}$ inch $\times$ 2 inches shall be capable of being doubled over cold until the flat sides come in close contact without cracking.

WORKMANSHIP.—All workmanship shall be strictly first-class, and equal to that of the Intercolonial Railway Bridges over the Miramichi and Ristigouche. When the bridge is tested, it will be covered with locomotives from end to end, and the centre deflection shall not exceed one two-thousandth part of the span.

A. L. LIGHT.

Quebec, 13th October, 1875.

APPENDIX No. 25.

IRON BRIDGES.**GRAND TRUNK RAILWAY,****CHIEF ENGINEER'S OFFICE,***Toronto, March 6th, 1876.***MY DEAR SIR,**

I have looked over the several plans of your bridges, as received from different manufacturers, and I beg to say that they are all of the Pratt truss principle, with the exception of two rivetted lattices: one from Mr. Leighton, of Rochester, and one from the Niagara Bridge Works.

They are all of different lengths, weights and construction, each builder calculating from a given working strain of his own, and making his bridge as deep as he thinks proper.

I am sorry that I had not time to go through the calculation of each separately, but in glancing over them, I saw plainly that part of them were very light in construction and others heavier. The Rivetted Lattices were more satisfactory than the pin connections, but all lacked safety in computation, the working strains being generally too high.

I give you my opinion from practical experience, I do recommend bridges with pin connections, when Rivetted Lattices can be obtained at their present prices. I am in favor of the Lattice Bridges, because when once well made of a good class of iron, they are permanent, and do not require adjusting, as is the case with the pin connections.

I may state that after having looked over the drawings and strains, I cannot but conclude that none are satisfacto-

ry either to yourself or a credit to the manufacturers. What I would recommend would be to return each manufacturer his drawing, and if you decide on Rivetted Lattices or pin connections, have drawings and specifications furnished accordingly.

I remain, my Dear Sir,

Your obedient Servant,

G. HUGHES,

Bridge Inspector.

APPENDIX No. 26.

S.S. "SARMATIAN,"

RIVER ST. LAWRENCE,

15th July, 1876.

A. L. LIGHT, Esq.,

MY DEAR SIR,

Referring to the hurried conversation which we had this morning, as the steamer was leaving Quebec, I only wish to add to what I said to you, that I am in favor of lattice girders for all ordinary spans above 40 feet, and plate girders for spans under 40 feet. I do not like the three pin connection bridges we have on the Intercolonial Railway.

They were adopted by the Government and the Commissioners, not because they were better, but simply because they were a shade cheaper than the tender for the splendid English lattice of Fairbairn & Co. We actually had a tender for lattice girders considerably under the pin bridge accepted tender, but I did not recommend it, as I considered it too light. There are only one or two things that I shall always regret on the Intercolonial, and one of them is the erection of the iron superstructure of the Miramichi and Ristigouche rivers not being so satisfactory as I would wish. I made a modified remonstrance against its adoption at the time; but as I had just succeeded in getting iron bridges for the whole line after a two years' bitter struggle, in which I had to fight both Commissioners and Government, I was too well satisfied with the result of the struggle and the adoption of really good iron bridges for all the rest of the line to be particular about the kind of superstructure used at the places mentioned. However, if it had to be done again, I would most undoubtedly insist that the English lattice should be erected over the rivers referred to as they are throughout the rest of the

line in preference to the Philadelphia pin bridge, which I consider objectionable in some important particulars. The Lattice which I favored would outlive half a dozen of the bridges erected, I feel assured.

Yours faithfully,

SANDFORD FLEMING.

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APPENDIX No. 27.

IRON BRIDGING.

Quebec, 31st March, 1876.

CHARLES O'DELL, Esq.,

Chief Engineer to Contractor.

DEAR SIR,

In reply to your question as to the description of Iron Bridging to be used on the N. S. Railway, and whether the plans lately submitted by the several makers have been found satisfactory.

I would remark that I have recommended the adoption of "Riveted Lattice Girders," and as none of the designs were entirely satisfactory, I have been instructed to prepare fresh drawings and specifications, which will be finished as soon as possible.

I remain, Dear Sir,

Very truly yours,

A. L. LIGHT.

APPENDIX No. 28.

SPECIFICATIONS, IRON BRIDGES.

No. 1.

General Specification for Iron Truss Bridges for the EASTERN Division of the Quebec, Montreal, Ottawa and Western Railway of Canada, Province of Quebec.

The works comprised in the following specification are the furnishing of all materials, labour, plant and implements required for the entire completion and erection of the following Wrought Iron Bridges.

The Bridges are to be designed for single Track, both through and deck of the spans shown in the schedule attached. They will have iron floor beams and *four* longitudinal iron stringers.

Tenders must be based on the following general specification, and the strength of materials and workmanship must be in strict conformity herewith.

Each manufacturer must submit details of his own system, which must be of the *rivetted Lattice* form of construction. It will be necessary however, to submit with each tender the following, viz :

1st. Complete working drawings, shewing exactly all details and dimension of parts.

2nd. Diagrams of strains and sectional areas of each for comparison with the Government standard.

3rd. Statement shewing the calculated weight of each span, with its iron flooring complete exclusive of cross ties, rails, &c.

4th. Working specifications in full detail descriptive of the Plan, the character and quality of the iron proposed to be used and the nature of the workmanship, &c.

GENERAL SPECIFICATION.

Each span of through bridge must have a clear width of 15 feet between trusses, and a clear height above the rails of not less than 20 feet, and for long spans not exceeding an eighth of the Span, Deck Bridge Trusses to be not less than 12 feet centres for spans of 125 and under, and wider in proportion to length and height of Truss.

Each span, according to length, must be constructed with a permanent camber of one twelve-hundredth of the span, and it must return to this camber after being tested with maximum loads.

Each span must be constructed entirely of tough wrought iron of the very best uniform quality used in bridge works.

Each span must be designed for a maximum rolling load in addition to the weight of the bridge of 3,000 pounds per foot run of span, with a panel load of 5,000 pounds per foot.

The several members of each span shall be so proportioned that the iron shall not be exposed to a greater tensile strain than 10,000 pounds persquare inch on the net section of the bottom flanges and 8,000 pounds on the floor system, and 6,000 lbs. per square inch upon the diagonals or web system, unless entirely in tension when they may be 10,000 pounds.

The compressive strain upon the gross section of the upper flanges, struts and end braces shall not exceed 8,000 pounds per square inch for short members. The compression in long members to be reduced by Gordon's formula using 36,000 pounds per square inch as the ultimate strength of wrought iron in compression, with a factor of safety of five. *The length of struts and braces to be taken from chord to chord.*

Iron used in compression and under transverse loads to be of approved consistency, iron used in tension to be double rolled and of an ultimate strength of 55,000 to 60,000 pounds per square inch—no permanent set under 25,000 pounds per square inch, measured by approved multiplying instruments and of such toughness that a flat bar up to a thickness of one inch by two inches or any greater

width shall be capable of being doubled over cold until the flat sides come in close contact without showing signs of fracture.

The quality of iron being of paramount importance, the rolling for parts subjected to tension must be done under close inspection. It must be made from the best approved grey pig, tested in the "Muck" bar, afterwards double rolled, and all material used shall undergo satisfactory tests before and during manufacture.

The contractor must, at his own cost, provide for and make all tests and furnish portions of such plates, angle iron, &c., as the Engineer may require for the purpose of ascertaining if they come up to the before mentioned standard.

No testing of material or inspection during manufacture shall be taken to mean an acceptance of the work, or material, in any way to relieve the manufacturer of responsibility, and the Engineer shall have power, at any time, to reject the whole or any part on account of defects.

The workmanship must be strictly first-class. All riveted work shall be made from iron templets, no drifting allowed. The whole being subject to rigid inspection during manufacture.

The whole work must be arranged and designed, so that no part can retain water or moisture.

Ample provision must be made for expansion and contraction over piers and abutments.

All iron work, before leaving the works, and as soon as possible upon being formed into the required shape, shall receive an approved ante-corrosive coating. So soon as erected, all damaged parts or fresh surfaces must be cleaned and recoated. The whole, after erection, shall receive two additional coats of approved description and color.

This general specification will apply to draw-bridges as well as fixed spans. They will be similar and equal in all respects to the Lattice draw over the Hudson River, at Albany, N. Y.

The Bridges will be tested after completion in the following manner :

They will be covered with Locomotives from end to end, weighing with their Tenders not less than 60 tons each, and the centre deflection shall not exceed one fifteen hundredth part of the span.

Approved.

(Signed,) A. L. LIGHT.

Quebec, 20th May, 1876.

No. II.

General specification for Iron Truss Bridges for the EASTERN AND WESTERN sections of the Quebec, Montreal, Ottawa and O. Railway of Canada, Province of Quebec.

1st. The works comprised in the following Specification are the furnishing of all materials, labor, plant and implements required for the entire completion and erection of the Wrought Iron Bridges on the above mentioned Railway between Quebec, Montreal and Ottawa, according to the annexed Schedule.

2nd. The Bridges are to be designed for single track both through and deck, of the spans shewn in the Schedule attached; they will have iron floor beams and *two* longitudinal iron stringers, six (6) feet apart between centres.

3rd. Tenders must be based on the following general specification, and the strength of the materials and workmanship must be in strict conformity therewith.

4th. Each manufacturer must submit details of his own system. It will be necessary to submit with each tender the following, viz.:

1. Complete working drawings shewing all details on enlarged scale and dimensions of parts.

2. Diagrams of strains and calculations, and sectional areas of each member for comparison.

3. Statement shewing the calculated weight of each span with the iron flooring complete, exclusive of cross ties, rails, &c., &c.

4. Working specification in full detail, descriptive of the plan, the character and the quality of the iron proposed to be used and the nature of the workmanship.

GENERAL SPECIFICATION.

5th. Each span of through Bridge must have a clear width of fifteen feet between trusses and a clear height above the rails of not less than 18 feet. Deck Bridge trusses to be not less than twelve feet centres for spans of 125 feet and under, and wider in proportion to length and height of truss.

6th.—Each span according to length must be constructed with a permanent camber of one twelve hundredth of the span and it must return to this camber after being tested with maximum loads.

7th. Each span must be constructed *entirely* of tough wrought iron of the very best uniform quality, except joint and the base blocks, which may be of cast iron of approved quality.

8th. Each span must be designed for a maximum rolling load in addition to the weight of the bridge, for 50' feet spans, 4,000 lbs, for 100 to 130' spans, 3,000 lbs, for 150 to 160' spans, 2,800 lbs, for 200' and over, 2,600 lbs. and all with a panel load of 5,000 pounds per foot.

9th. The several members of each span shall be so proportioned that the iron shall not be exposed to a greater tensile strain than 10,000 lbs. per square inch on the net section of the lower chords after deducting rivet holes, and 6,000 lbs. per square inch on the diagonals or web system, unless such diagonals are entirely in tension when the strain may be 10,000 pounds.

10th. The compression strain upon the gross section of the upper chords, struts and braces shall not exceed 8,000

pounds per square inch for members not exceeding 15 diameters. The compression in long members, exceeding 15 diameters to be reduced by Gordon's formula, using 36,000 pounds per square inch as the ultimate strength of wrought iron in compression with a factor of safety of 5=7200. The length of struts and braces to be taken from chord to chord.

11th. Iron used in compression and under transverse loads to be of approved texture. Iron used in tension to be double rolled and of an ultimate strength of 55 to 60,000 pounds, no permanent set under 25,000 pounds per square inch measured by approved multiplying instruments, and of such toughness that a flat bar up to the thickness of one inch by two inches, or any greater width, shall be capable of being doubled over cold until the flat sides come in close contact, without showing signs of fracture.

12th. The quality of iron being of paramount importance, the rolling for parts subjected to tension must be done under close inspection, it must be made from the best grey pig tested in the muck bar, afterwards double rolled and all materials used shall undergo satisfactory tests before and during manufacture.

13th. The contractor must at his own cost provide for and make all tests and furnish portions of such bars, plates, angle iron, &c., as the engineer may require for the purpose of ascertaining if they come up to the before mentioned standard.

14th. No testing of materials or inspection during manufacture shall be taken to mean an acceptance of the work, or materials, or in any way to relieve the manufacturer of responsibility, and the engineer shall have the power at any time to reject the whole or any part on account of defects.

15th. The workmanship must be strictly first class. All riveted work shall be made from iron templates, no drifting allowed, the whole being subject to rigid inspection during manufacture.

16th. The whole work must be arranged and designed, so that no part can retain water or moisture.

17th. Ample provisions must be made for expansion and contraction over piers and abutments.

18th. All iron work before leaving the works, or being exposed to rust shall receive an approved ante-corrosive coating; so soon as erected all damaged parts, or fresh surfaces, must be cleaned and recoated. The whole after erection shall receive two additional coats of approved description and color.

19th. The Bridges will be tested after completion, in the following manner:

They will be covered with locomotives from end to end, weighing with their tenders, not less than 60 tons each, and the deflection at the centre shall not exceed one fifteen hundredth part of the span.

A. L. LIGHT.

Quebec, 18th Sept., 1876.

Contractor's Specification for Iron Truss Bridges, North Shore Railway, Canada, Province of Quebec.

The Bridges are to be designed for single track railway bridges of the following spans, with *wooden* stringers and cross ties.

150 feet clear span

160 " " "

230 " " "

Pivot draw 20 openings— 50 feet clear each.

" " 2 " 100 " "

M. LOAD.—The Bridges are to be calculated to sustain the passage of two sixty-ton engines, followed by loaded cars weighing *two thousand pounds* per lineal foot of bridge. The engines throwing thirty tons on drivers of a wheel

base of twelve feet. In addition to this load is to be considered the weight of the iron work itself together with the flooring.

CHORD STRAINS.—The chord strains are to be computed supposing the centre driver to have reached parcel point and the rest of the train covering the bridge as above described. The strains are to be calculated for such position of the load which will produce the maximum strains upon the different members.

STRAINS.—Under the foregoing loads the maximum strains produced shall not exceed the following :

Tension.....	10,000 lbs	per square inch
Shearing.....	7,500 "	"
Compression	10,000 "	"

FACTORS.—Factors of safety for Tension 6.
" " Compression 5.

The latter shall be determined according to Gordon's formula (in all cases), and two-thirds the amount so found shall only be allowed for members with pin connections at both ends, and five-sixths for members square at one end and with pin connections at the other.

FLOOR BEAMS.—In floor beams the compressive strain shall not exceed 9000 lbs per square inch of total section, and the tensile strain on the bottom chord of the same shall not exceed 10,000 lbs per square inch of nett section.

MATERIALS.—Wrought iron in tensible members shall be double rolled iron of an ultimate strength of from 55,000 lbs to 60,000 lbs per square inch, with an elastic limit of about 30,000 lbs per square inch, and of such toughness that a flat bar of $\frac{3}{4}$ in x 2 in shall be capable of being doubled over cold until the flat sides come in close contact without cracking. Iron used in compression members to be of proper hardness and toughness, and in quality equal to the best used in American bridge work.

Cast iron will only be permitted in minor details as pedestals, shoes, &c. It is to be of the best quality of soft grey metal sound and free from flaws.

DETAILS.—Pin connections to be used throughout the bridge, the heads and eyes of tension members are to be made of such form and dimensions as to secure an excess of strength through the eye of 80 per cent over the strength of the bars.

PIN HOLES, &C., &C.—All pin holes to be drilled to 1-32 of an inch, all eye bars shall be tested to a strain of 20,000 lbs per square inch to prove the perfectness of iron and workmanship.

SCREW ENDS AND EYES.—All screw ends and eyes of counter and lateral rods to be enlarged so as to secure an excess of strength above the strength of the rods.

COMPRESSION MEMBERS.—Compression members to be made up of plates and angle irons, well riveted together, with their abutting joints truly squared. When hollow members are used, they are to be made of from $\frac{1}{4}$ to $\frac{1}{2}$ in excess of the actual computed strength required for same. This general specification shall apply to the draw-bridges as well as the fixed spans.

TURN TABLES.—Turn tables to be centre bearing tables, so arranged that the entire dead weight of the structure may be carried by the centre pivot, or by means of centre adjustments be thrown partly on the wheel circle.

CENTRE PIVOT.—The centre pivot to be of such proportions that the compression strains per square inch shall not exceed 2,000 lbs. per square inch.

WHEELS.—The wheels to be not less than 18 in., nor more than 24 in. in diameter, and of sufficient number to avoid a strain of over 3,000 lbs per lineal inch of line of contact. The drum is to be sufficiently stiff to secure a proper distribution of the moving load over the whole wheel circle. All workmanship to be first-class in every respect.

PAINTING.—The iron work to be painted one coat of mineral paint before leaving the works, and another coat after the bridges are erected complete.

Strain sheets must be submitted with plan and specification of bridge before any tender will be accepted, and subject to the approval of the Government Engineer.

All tenders to state the price in gold, for bridge erected at the site with all freight charges and duties paid.

Tenders will be received up to Tuesday, January 25, 1876.

Tenders to be addressed,

HON. THOS. MCGREEVY,

North Shore Railway,

Quebec, Canada.

APPENDIX No. 29.

IRON BRIDGES

Quebec, 8th September, 1876,

HON. H. G. MALHIOT,

Chief Commissioner, &c.

DEAR SIR,

According to your wish, I send the least loads I can recommend for the Iron Bridges about to be contracted for. They are as follows:

ROLLING LOADS.

4,000	pounds per foot for 50 feet spans including draws.
3,000	" " " 100 "
2,800	" " " 150 to 160 feet spans.
2,600	" " " 200 feet spans and upwards.

Panel Load and Floor system arranged to sustain 5,000 pounds per lineal foot of Track.

I only recommend this reduction from my first specification, (which was arranged for Lattice Girders,) if pin connections are substituted; the latter admitting of a lighter form of construction; and also, on the sole condition that the contracts are let to approved Firms only, of the highest repute, who *make* their own iron. This making of the iron is *indispensable*, and I cannot too strongly recommend it to your notice, as it will enable the Government inspector to watch the metal from its different stages of manufacture; or from the approved pig to the finished bar, as contemplated by the specification—thus ensuring good material, which is of paramount importance. With inferior makers, who buy their iron in the cheapest market, no such supervision can be maintained, and an indifferent article is sure to be the result.

The specification, as originally prepared by me, was for *Lattice Girders* of the most approved modern construction. You are aware that I recommended these for this Government work at this time, as owing to the present extremely low price of iron, they could have been obtained at an insignificant increase of cost, if any, over the American pin connection bridges. They could safely have been used at the highest speeds, and would have lasted much longer than the latter.

The rolling load of 3,000 pounds per lineal foot was adopted after careful consideration. It is not at all excessive for lattice girders, especially in a snowy climate, where from three to four engines must be generally used to open the line. Iron is greatly reduced in strength by extreme cold, and the bridge itself would often be heavily loaded with ice in addition. The loads used in England, (by eminent practical engineers,) where lattice girders are almost exclusively used, are a ton and a-half, or 3,360 pounds per foot.

Pin connections allow the strains to be more directly applied, and therefore admit of lighter and cheaper construction, but this lightness causes vibration, which prevents their use at high speeds, and has a direct tendency to wear out the structure.

I remain, Dear Sir,

Faithfully yours,

(Signed,)

A. L. LIGHT.

APPENDIX No. 30.

9th December, 1876.

HON. THOMAS MCGREEVY,

Contractor, &c., Q. M. O. & O. Railway.

DEAR SIR,

I return the plans of Iron Bridges for spans of 150 and 160 feet, as submitted by your engineer. They are disapproved not being in accord with the revised specification—notably clause 4 and subsections No. 1, 2, 3 and 4. This specification was arranged by Mr. Petersen and myself on the 18th September last, for pin connection bridges, at which date a reduction of Rolling Load was recommended by the engineers, and consented to by the Commissioners on the distinct understanding, however, that the work should be let to approved firms only, who made their own iron.

It was understood at the time that this information would be communicated to you by the Secretary of the Commission.

To prevent misunderstanding I enclose a copy of the revised specification, which differs from the original only in the arrangement of the Rolling Load.

I remain, Dear Sir,

Yours truly,

A. L. LIGHT.

HON. THOMAS MCGREEVY,

3rd January, 1876.

Contractor, &c.

DEAR SIR,

I have received from your brother—professing* to act for you—diagrams of strains of iron bridges, 154 and

164 feet span for approval. Though these strain sheets may be of the required standard I am not in a position to properly consider them, until I receive the other information required by the 4th clause of the approved specification, including sub clauses 1, 2, 3 and 4, all this was particularly explained in my letter of the 9th of December, to which I again refer you.

To save time, I have to state that I can approve of no data that does not literally fulfil, in the most complete manner, the requirements of the above clauses.

I remain, Dear Sir,

Yours truly,

A. L. LIGHT.

APPENDIX No. 31.

WOODEN BRIDGES.

Quebec, July 12th, 1876.

CHARLES ODELL, Esq.,

Contractor's Engineer.

DEAR SIR,

Will you please furnish me the following information with as little delay as possible, viz: tracings showing all the dimensions of every part of the truss bridges actually built for the following rivers:

1. Champigny.
2. Cap Rouge.
3. River Noir.
4. Aux Pommes.
5. Jacques Cartier.
6. Portneuf.

And any other bridges you may have commenced to frame or have received plans for, between Portneuf and Three Rivers.

I wish the Jacques Cartier and Portneuf first as most important.

I desire this information as promptly as possible, in the first place, to enable the correct heights of piers and abutments now building to be fixed, which you are aware, cannot otherwise be done with safety; and, secondly, so that these structures, if not correctly designed, may have such alterations made as shall be found necessary in advance, so as not afterwards to delay the work.

I remain, Dear Sir,

Faithfully yours,

(Signed,)

A. L. LIGHT.

APPENDIX No. 32.

WOODEN BRIDGES.

22nd November, 1876.

HON. THOMAS MCGREEVY,

Contractor, &c.

DEAR SIR,

Some months ago I received your engineer requesting him to furnish me tracings of the wooden bridges framed by Boomer & Co., last year before the works were assumed by the Government. These drawings were required to save delay and inconvenient changes hereafter.

The wooden bridges of course have to be of the same strength as the standard for iron bridges, lately adopted on the eastern and western divisions of the railway, viz: A rolling load exclusive of static load of 4,000 pounds per lineal foot, for spans of 50 feet, 3,000 pounds for spans of 100 to 130 feet, 2,800 pounds for spans of 150 to 160 feet, and 2,600 pounds for spans of 200 feet and upwards, all with a panel load of 5,000 pounds per lineal foot.

In the copy of my letter to Mr. Odell, attached, you will see that the Pont Rouge and Portneuf Bridges are especially referred to. These from their size being the most important. I now understand from Mr. Lindsay, that these latter bridges are being prepared, and I have received no drawings for them. If this is really the case, it is to be regretted as unless they come up to the approved standard and the style of their framing is unobjectionable, they cannot be accepted. It will of course be easier to make any changes that may be required while the staging is up, and the work in progress, otherwise the whole may have to be taken apart and delay and considerable expense incurred hereafter.

Please have these drawings furnished and oblige me by instructing your employées to carry out literally any changes or additions marked on the plans by me.

I remain, Dear Sir,

Your obedient Servant,

A. L. LIGHT.

APPENDIX No. 33.

Quebec, 23rd November, 1876.

HON. H. G. MALHIOT,

Chief Commissioner, &c.

DEAR SIR,

Herewith I beg to call your attention to the enclosed correspondence with the Hon. Thos. McGreevy and his engineer on the subject of wooden bridges. Some of these bridges were framed before the works came under the supervision of the Government, and I now find they are of less strength than the standard lately adopted for the iron bridges.

There is no difficulty up to a certain span in making wooden bridges as strong as iron ones, and there is every reason that they should be even stronger, as at the outset they are subject to similar strains and become rapidly weaker through decay.

The bridges over the Jacques Cartier and Portneuf are especially important from their heights, while the greater width of span of the former, requires that it should be framed in the very best manner, to render it efficient and safe.

I would suggest that the contractor's attention be immediately called to this matter by the Commissioners, to save delay and unnecessary expense hereafter.

I remain, Dear Sir,

Your obe't. Servant,

A. L. LIGHT.

APPENDIX No. 34.

26th December, 1876,

HON. THOS. MCGREEVY,

Contractor, &c.

DEAR SIR,

I am in receipt of your's of the 22nd instant, on the subject of the wooden bridges, enclosing strain sheets, plans, bills of material, &c., with a letter from your engineer.

I also note your statement "that all these bridges were constructed so far under the authority, direction, and by the specification of the Engineer of the late North Shore Railway Company, and which specification and contract formed the basis of the present contract, and not objected to by you while Government Engineer, or since, or alluded to in the joint report of Mr. Baillairgé and yourself, dated 13th March, 1875. I consider they are adopted, and in keeping with what is required by the contract."

All the above is assented to, down to, and including the paragraph stating that these bridges were constructed under the authority, directions and specifications of the late chief engineer of the Railway Company.

Where you further state "that these specifications are the basis of the contract, and not objected to by you, while Government Engineer, or since, or alluded to in the joint report of Mr. Baillairgé and yourself, dated 13th March, 1875, I consider they are adopted, and in keeping with what is required by the contract." This clause, I think, requires modification. The above plans, &c., were not objected to by me, as up to the date of your letter just received, enclosing them, they had never been submitted. I always considered them in the same category as the iron bridges, rails, piers abutments, rolling stock, stations, &c., which, by clause 1 of the contract, were to be made in conformity with the Government requirements from time to time.

I officially asked your engineer for these documents in July last, then in his possession, in order that I might see in advance if these bridges were such as I could approve. They are now just to hand after several of them have been erected, and I find the trusses generally from 20 to 50 per cent lighter than the specifications as arranged for the iron bridges, which I consider none too strong.

This deficiency fortunately can yet be strengthened without losing any of the original material by merely transposing some of it into smaller structures.

I have strongly recommended that this be done, both on the bridges already erected, and those yet to be built.

The flooring also on all bridges now made on the old specification, is *unsafe*. It must be changed to conform with the new plans lately submitted and approved. The floor beams being enlarged on those yet to build, to 7" x 14" laid 2 feet centres with 4 instead of 2 longitudinal stringers. The cross ties being 8" x 8" x 14 feet long, laid 16 inch centres, with the necessary guard rails properly locked *on* and bolted as shewn, which will make the track *safe*.

The first to be strengthened is the Jacques Cartier Bridge, a sketch for which is enclosed, shewing the necessary additional material required.

The estimated cost of strengthening this truss, at your prices, after deducting the value of changed material, is \$1,936, or an increase of about 17 per cent.

Diagrams shewing the mode of strengthening the other bridges will be sent as required.

I am, Dear Sir,

Yours truly,

(Signed,)

A. L. LIGHT.

APPENDIX No. 35.

PASSENGER STATION.

Quebec, June 24th, 1876.

HON. THOMAS MCGREEVY,
Contractor.

DEAR SIR,

I beg to call your attention to a few matters in connection with the work, at the Passenger Station, at the Palais.

The inspector reports that the foundations for stone walls are being prepared, and that the men have had orders to put in timber *without* concrete. If you refer to the general specification you will find that concrete is to be put in and timber bedded in it, under all walls. Timber cannot be allowed to be used by itself. Good concrete must either be put in by itself or the specifications for foundations strictly adhered to.

I must also call your attention to the necessity of having the foundation for the Express Office, Baggage Room and Gentlemen's W. C. put in, before any more brick work is proceeded with in that vicinity, in order to have the entire work thoroughly bonded.

If these matters are not carried out in a regular and workmanlike manner, I shall be under the necessity of stopping this irregularity, until proper details and materials are ready, to carry out the work in accordance with the general specification.

I must inform you that in future, before any orders are given to your agents to depart from any approved plans and specifications, the nature of such orders must first be communicated to this office for approval.

I remain, Sir,

Your obedient Servant,

A. L. LIGHT.

APPENDIX No. 36.

Quebec, July 22nd, 1876.

T. J. LEPAGE, Esq.,
Architect, &c.

SIR,

I beg to acknowledge the receipt of yours of the 22nd inst.; repeated absences and important business have prevented me from sooner replying to it.

With reference to the plans of the Palais Station, originally prepared in this office, and afterwards altered in several important particulars by the contractor, I would remark that the Commissioners disapproved of these alterations as being out of character with the requirements of a railway, and after due consideration, decided to keep to the general design of the original plans, with the exception of the Mansard Roof over the offices, which, simply from motives of economy to the contractor, they have allowed to pass.

You will thus see that the original plans, with the above exception, having been approved by the Commissioners and myself, are to be mainly carried out, and the question of responsibility need give you no further trouble.

I remain, Sir,

Yours truly,

A. L. LIGHT.

APPENDIX No. 37.

Quebec, 10th November, 1876.

HON. THOS. MCGREEVY,

Contractor, &c., &c.

DEAR SIR,

The inspector reports that unseasoned and unsound lumber has been delivered and prepared for covering the roof of the Passenger Station, and also unseasoned hemlock for the flooring of the offices.

It is intended by the specification, to have well seasoned and sound *Pine* Lumber in all cases. The kind of lumber that has been delivered for this work, of a first-class passenger station you will see, is unfit for the purpose and would not be allowed in any other work of the kind.

Oblige me by giving the matter your prompt personal attention, and have the lumber replaced by seasoned pine.

I remain, Dear Sir,

Yours truly,

A. L. LIGHT.

APPENDIX No. 38.

*Quebec, Montreal, Ottawa & Occidental Railway,
Engineer's Office, Eastern Division,
Quebec, 20th April, 1877.*

HON. THOS. MCGREEVY,
Contractor, &c.

SIR,

The Commissioners have requested me to inform you, that almost daily complaints are made by Mr. Mahieu, their inspector, that unseasoned, unsound and unfit materials are being used in the fittings of the Palais station, (viz. : doors, windows, brackets, floors.) I have sent Mr. Hoare several times to try and arrange this matter with your subordinates, but apparently without effect, as the inspector still reports unfavorably.

I now have to notify you that I will sharply condemn any of the above fittings that are not strictly up to specification.

I am, Sir,

Your obedt. Servt.,

A. L. LIGHT.

APPENDIX No. 39.

ROLLING STOCK.

GOVERNMENT ENGINEER'S OFFICE,

Quebec, 5th November, 1875.

MR. HARDMAN, Mechanical Engineer, &c.
*General Superintendent of Machinery for
 Contractor, North Shore Railway.*

DEAR SIR,

I return the specifications for Passenger and Freight Engines, you have prepared at my request for the North Shore Railway.

I approve of their general dimensions, weight, and character, as being just what is required for the mixed business, that may be at first anticipated on this line.

Everything connected with the North Shore Railway, as you are aware, must be first-class, I reserve to myself therefore, the right to supplement and alter these Engines during construction, should anything essential hereafter be found to have been omitted.

I remain,
 Sir,
 Your obedient Servant,

A. L. LIGHT.

HON. H. G. MALHIOT,

Chief Commissioner Q. M. O. & O. Railway.

DEAR SIR,

Mr. McGreevy, yesterday, having called the attention of the Commissioners to the question of rolling stock,

I have thought it well to prepare a full description of what has hitherto taken place in regard to this matter and herewith enclose, and you will confer a favor upon me by carefully considering the circumstances herein described. Will it not be well to ascertain as soon as possible, the real state of forwardness of the stock already ordered? According to Mr. McGreevy's account it is as follows:

50	Box freight Cars.	
4	First-class	"
22	Cattle	"
80	Platform	"
7	Baggage	"
		} specification not submitted.

If the construction of the bodies of these cars has gone so far that they are now practically unalterable, I would at least recommend that the running gear upon which their freedom from accident mainly depends be changed and made same as Grand Trunk standard—this will greatly increase their safety as well as the economy of their maintenance and can be done with but little loss, as the present running gear if discarded can be again used by the makers on other less important railways.

If the four first-class cars now under construction are not too far advanced, they can be easily converted into second-class, the difference in value between the classes being principally their interior and external finish. The general plan of running gear and framing being similar in both.

If the finishing has too far progressed, then these four first-class cars (with changed running gear) may be used with advantage on the Saint Jerome and Piles Branches, leaving twelve cars still to be ordered for the main line, which I would strongly recommend should be made exactly similar to those ordered by Mr. McDonald for the western division on purely Grand Trunk Railway latest standard.

The specifications for two classes of these cars it has never been pretended have been approved by me, viz: the baggage and the platform cars of which latter there are a great number (80.)

These at any rate have no right to be considered as fixed, and should be made to the standard approved by the Commissioners. Those that have been lately delivered by the contractor are worth about 75 dollars per car, or 25 per cent less value than the approved plan, and are only fitted for construction purposes.

I remain, Dear Sir,

Very truly yours,

(Signed,) A. L. LIGHT.

Quebec, 11th June, 1876.

To the Commissioners of the Q. M. O. & O. Railway.

GENTLEMEN,

I desire to bring before your notice a point upon which Mr. McGreevy and I differ, viz: the question of approval of specification. I received a few days ago from him copies of certain specifications upon which the rolling stock for this railway is now being made, and which he says were approved by me. They cover five classes of cars, viz: first and second-class, box, stock and emigrant cars, while it would appear that seven descriptions of cars are being made, two are therefore on unapproved specifications. Twenty platform cars of this description have been recently delivered here, and are inferior to the same car approved lately by the Board of Commissioners.

The contract stipulates (clause No. 1), "that it is fully understood and agreed by and between both parties hereto, that the profiles, plans, working drawings, and detailed specifications of the different works, structures, buildings and equipments shall be made by the said contractor, and fully approved by the Government Engineer before work is begun upon them, and that all work and material shall be subject to his inspection and approval before being accepted and paid for by the government."

The contractor has ignored the first part of this clause, and for the rails, bridges and rolling stock, the three most

important items of his contract, amounting in aggregate value to \$1,668,960, he has furnished no plans with the exception of those imperfect plans (if indeed they can be so called) sent in last March by the several American bridge builders.

The facts of this case are as follows:—Early in March last, the contractor brought many car builders to Quebec, to contract for his rolling stock, who were severally sent to see if I would approve of their self made and loosely drawn specifications. Having no plans to compare with these documents, I was unable to form a correct opinion of their merits and refused them. Seeing that no plans were being prepared by the contractor, and that the delay was occasioning much dissatisfaction against the Commissioners and myself, and having no staff at my disposal capable of preparing such plans, and knowing the paramount importance of *one uniform standard of rolling stock*, I determined to recommend the adoption of the last improved Grand Trunk Railway standard which is substantial, safe and well adapted to this climate.

On the 25th March, I therefore requested Messrs. Hickson & Hanneford to let me examine their plans. Mr. Hickson frankly ordered his master mechanic to put his workshop at my disposal, and give me the benefit of his advice and experience.

After two days careful examination of all their stock, I selected the last most approved patterns as a standard, with the addition of the American car builders "enlarged axle" which the Grand Trunk Railway people strongly recommended (in furnishing a new line) and which they are adopting as fast as the old axles wear out. The master mechanic at my request also set his draftsmen to trace copies of the plans of stock selected, with as little delay as possible for the cost of which tracings (\$180) I became responsible.

On my return to Quebec, Mr. Thomas Muir, car builder of London, Ontario, informed me he had closed a provisional contract with Mr. McGreevy for five classes of cars, subject to my approval. I told him that being unable to get plans, as the contract provided from Mr. McGreevy, I had decid-

ed to recommend the Grand Trunk Railway standard to the Commissioners, that I expected plans and would do nothing till I received them. Mr. Muir thought this very hard, as it would delay him greatly, and assured me that his contract was based strictly upon the Grand Trunk latest standard.

On the 1st April, Mr. Muir again called with the Contractor's Engineer, Mr. Odell, and they both represented how sadly they were delayed by my persistent refusal of their specifications, which they stated were purely G. T. Standard. Mr. Odell, acting as agent for Mr. McGreevy, not only offered to guarantee this if I would pass his specifications, but handed me a copy of a clause in their agreement with Mr. Muir, which bound him to make the cars in accordance therewith.

This clause read as follows: "The whole to be constructed and finished in accordance with the specification submitted by the Ontario Car Co.'y, under date of 9th March, 1876, hereunto annexed, and which have been approved of. Cars to be inspected at the Ontario Car Co.'y works in London, Ontario, at any time during construction. The first car of each class, when inspected and received by Mr. McGreevy or his agent, and the Government Engineer of said Railway, to be made sample to which standard the remaining cars of the several classes shall be made to conform, and be so accepted. But, if during construction, anything is found wanting in the said specification to bring the said cars up to the standard of the G. T. Railway, the same shall be at once remedied without any additional charge or cost, the intention being that the price agreed upon herein is intended to be for a car equal, in every respect and particular, to the cars of the G. T. Railway."

To the above clause I would call most particular attention. I marked it clause A. I told Messrs. Odell and Muir that it seemed fair; but as they had no plans, I meant to adopt those of the G. T. Railway (expected shortly) with the Master Car Builder's axle in addition. To this they replied they had no objection, and that if I would forward these plans, when received, to Mr. Muir at London, they would be adopted. Not wishing to delay the work unne-

cessarily, I then endorsed the following on the corner of the five specifications: "Approved subject to be hereafter changed and revised in accordance with clause A, and in accordance with detail plans hereafter to be furnished by me.—A. L. LIGHT."

I then considered, as I still do, this clause to be a sufficient rider upon my approval, as to admit of the cars being built to my satisfaction.

The plans and specifications were not received from the G. T. people until the 14th April, and on the 18th were laid before the Commissioners and approved by them. I related my interview with Messrs. Muir and Odell, and strongly advised that an inspector be appointed and despatched to the works where the cars were constructing, to report whether they really were being made to G. T. *latest* Standard; if not, that the Contractor be notified at once to stop the work and adopt the G. T. Railway plans in accordance with the understanding between me and his Engineer and Agent.

I further at once despatched to Mr. Muir, as agreed, copies of plans of Freight and Platform Cars, as I understood he intended to commence with these. The Commissioners will no doubt remember that I have always been strongly of opinion that an inspector should have been appointed and the Contractor brought to book.

I am now informed by Mr. McGreevy that he has commenced building numbers of cars on his own specifications which it will be seen from the letter of G. T. Railway Master Mechanic attached, is entirely different and inferior to their latest standard. If this is permitted, it is to be regretted, as the Government are thus getting different patterns to those which are being prepared for the portion of the same line between Montreal and Ottawa, where the G. T. R. standard has been adopted in its integrity by the Contractor. The inferior character of the trucks and running gear used on the Eastern Division is a most serious objection. They will not only be more troublesome and expensive to maintain, but if made without rigid inspection they will be *positively dangerous*. They should be made to conform to the stock building for the Western Division on

which the Contractor, as already stated, has adopted the Master Car builder's axle, the latest G. T. Railway springs, wheels and trucks, the Whitworth thread and all modern improvements.

Should it be conceded in the face of the facts which I have now laid before you, that the Contractor has a right to build what cars he pleases without furnishing the necessary plans stipulated in his contract, I can only regret that my earnest desire to forward the works by every means in my power has been used in an attempt to overreach me and impose inferior stock on the Government in a *very questionable manner*.

As you will perceive, I approved the specifications relying on Messrs. Odell and Muir's positive assurances that they were the same as the G. T. latest standard, and guarded my approval by the strong rider endorsed on the specifications, but the absence of plans made it very difficult to detect any departure from the standard insisted upon.

I have the honor to be,

Gentlemen,

Your obedient Servant,

A. L. LIGHT.

P.S.—I beg to call attention to the letter of the Master Mechanic of the G. T. Railway, to whom I have referred Mr. McGreevy's specifications for his opinion as to whether they are up to the standard required.

Montreal, June 7th, 1876.

DEAR SIR,

In answer to your letter of June 5th, relative to car stock for your railways, I beg to say that I have examined the tracing of the flat car truck and find that it is an exact copy of our drawing of a truck that we built for use under flat cars about 3 years ago; but since then we have built no more of the same design, because they failed to give us the satisfaction expected of them and we now use under

all our freight car stock, the lateral motion truck, of which we sent you full drawings and specifications. The tracing you send also shews an axle having a "C" journal, and of a lighter pattern than the Master Car Builder's standard, which I recommended you to adopt, and put on all your drawings.

With regard to the specifications of passenger cars you also send, I can only say that I have never seen them before; they are too vague and indefinite to be very binding on the contractor, and they vary very considerably in many important dimensions with the specifications I sent you as you may see by making a comparison.

Yours truly,

(Signed,)

R. BLACKWELL.

A. L. LIGHT, Esq., C. E.

Montreal, June 13th, 1876.

A. L. LIGHT, Esq.,

Quebec.

DEAR SIR,

In reply to your enquiry, I beg to say that the standard truck, both for box and platform cars is that known by the name of the "lateral motion truck" with elliptic springs.

It costs something like \$75 or \$80 more than that with the spiral spring, which we have only been in the habit of using under platform cars, and which we discarded because it was found that they would not stand the loading, and the difficulty of getting the springs properly tempered to stand the necessary compression, without becoming too much compressed, so as to become solid.

Yours truly,

HEBERT WALLIS,

Meck'l Supt.

Quebec, 19th October, 1876.

HON. H. G. MALHIOT,

DEAR SIR,

I hear from Mr. Gariépy that passenger and baggage as well as freight and platform cars are now building for this Division.

I would remind you that Plans have never been submitted by the Contractor for approval, (as the contract requires) and the cars are building upon a simple letter of agreement to be similar to Grand Trunk Standard.

If after delivery they turn out different to this standard it will be too late to change and disappointment will ensue. Allow me to suggest that the elaborate plans and specifications procured last spring from the Grand Trunk officials, should be given to the Contractor. They set forth in detail what their standard is and with accompanying specifications were approved by the Commissioners at the time.

Copies of these plans should also be given the Government Inspector, as without such data to guide him, it is very doubtful that the cars will be equal to those on the Grand Trunk.

The cars now making are let at inadequate prices, and on this account, even with close inspection under approved plans, it is difficult to get good work.

With *intermittent* inspection and no plans, it is probable that the stock for the Eastern Division will differ materially from that now delivered at Montreal. The latter were built upon the before mentioned G. T. R. plans and specifications obtained from this office. They were let at fair prices to a first-class maker and are *apparently* good; but as they have not been continuously inspected, there is no certainty of their excellence. This can only be determined by years of use.

Rolling stock, more than any other part of a railway, requires intelligent and constant inspection as upon its excellence the safety of travelling largely depends.

After completion it is impossible to judge of it, a little putty and paint makes the worst appear well for a time.

Uninspected wheels and axles *are especially dangerous, and should not be tolerated.* A broken wheel or axle may wreck a whole train. In the United States great caution is exercised, and but two or three firms entrusted with the making of wheels.

Stock prepared on proper plans and specifications and intelligently inspected, will assuredly wear from twenty to thirty per cent longer than uninspected stock.

The platform cars first delivered here were worth fully twenty-five per cent less than the last consignment.

The value of Rolling Stock as arranged for the Q. M. O. & O. Railway, aggregates \$755,820.

The cost of the best inspection need not exceed \$7,000, less than one per cent on the cost.

I therefore recommend that capable, sub-inspectors under the orders of the government inspector, be always kept at each establishment while the cars are being made. They should be competent car-builders.

I remain, Sir,

Faithfully yours,

(Signed,) A. L. LIGHT.

P. S.—I beg especially, to draw your attention to the following Report of Mr. Wm. Parker, C. E. of Boston, to the Government of N. B. Where the question of Rolling Stock is thoroughly reviewed.

St. John's, N.B., June 26th.

ROBERT JARDINE, Esq.,

Chairman of the Railway Commissioners
of New Brunswick.

SIR,

Yours of the 25th inst., asking my opinion as to the policy proper to be followed in procuring Rolling Stock for the Railway, and upon the proper rates for passenger fares, is before me.

It must be apparent that the greatest care in selecting Rolling Stock with reference to safety, is of the utmost importance, and that nothing in the way of trial of new makers should be attempted without extreme caution. This is especially true of wheels and axles, and I recommend that for passenger cars wholly, and for freight cars mainly, you resort only to those makers of wheels and axles, whose work has been proved and stands in the front rank for excellence, giving at the same time such encouragement to home enterprise as may be derived from orders of these articles for use on your ballast or gravel cars, and a few of your freight cars, until by continued and successful trial they shall be found certainly worthy of more extended use. Axles may, I think, be had best with reference to cost and quality combined, from England; wheels (being of cast iron) from the United States, where they are (of cast iron) almost exclusively used.

In selecting makers of locomotives a like course should be pursued, adhering to *one pattern* for each class of machines without deviation, that their repair and maintenance may be simplified and cheapened. There is little difference in essential properties among the several forms of locomotives now made, but a uniformity of pattern has been found, whenever adhered to, connected with marked economy of repairs.

Those machines which you have already procured are of good quality and established repute; and I would adhere to the same makers, while they continue to do as well, at moderate prices, encouraging at the same time your home mechanics, by occasional orders, made proportionately more frequent as their results shall be satisfactory—always, however, without variety of pattern.

Cars, whether for passengers, freight, or other uses, stand in a somewhat different position than wheels and axles, being subject to the foregoing remarks. The frames and bodies of cars are bulky, and subject to heavy charges for their transportation from abroad, while their manufacture does not call for any great degree of experience super-added to mechanical skill and faithfulness.

Materials for the construction are abundant in this province; so, I believe, is good mechanical labour; and I see

no unavoidable hazard, in preferring home artizans in this department at like prices. Looking, therefore first to quality and to proper seasoning of lumber, and under a *rigid inspection*, I recommend that your cars be made at home, allowing reasonable competition if it shall arise—the wheels and axles having been procured, as before stated.

Rates of fare for passenger travel have been extensively experimented on in the United States, and with the exception of a few densely populated lines, and for very long travel it is believed now that three cents per mile is the lowest rate expedient. Commutation for families, resident near the city, and for occasional excursion trains may be judiciously adopted at a reduction of not exceeding one-half.

I am, your obed't Servant,

(Signed,)

WM. PARKER,
Civil Engineer.

APPENDIX No. 40.

MUNRO & STEAR'S LETTER.

Quebec, 29th January, 1877.

A. L. LIGHT, Esq.,

SIR,

With regard to a letter in Mr. McGreevy's report of delay and damages, signed Munro & Stears, and dated 11th January, 1877. We positively deny ever having written or signed such a letter, or ever having seen it until shewn us by you to-day. We merely furnished Mr. McGreevy's officials with dates of beginning the building of Portneuf bridge, and of stopping the same at different times. We also deny ever having said anything of the delay caused by receiving different plans from the Government Engineer, and of his indecision, as we never received any plan from him, but got the only plan, we ever had from Mr. Odell.

Your obedient Servants,

(Signed,)

MUNRO & STEARS.

APPENDIX No. 41.

Q. M. O. & O. R'Y.

ENGINEER'S OFFICE, EASTERN DIVISION

Quebec, April 30th, 1877.

A. L. LIGHT, Esq.,

DEAR SIR,

As you have asked if we remembered the conversation between yourself and Messrs. Munro & Stears, relative to a letter published by Mr. McGreevy in his pamphlet, and signed Messrs. Munro & Stears, we have to state that we were present during the entire conversation which took place at the time, and that in our presence both Mr. Munro, and Mr. Stears, denied having written the letter and pronounced it a gross forgery.

Yours truly,

JOHN LINDSAY,

E. A. HOARE.

APPENDIX No. 42.

Q. M. O. & O. R.

DIVISION ENGINEER'S OFFICE,

Three Rivers, 23rd April, 1877.

A. L. LIGHT, Esq.,

Chief Engineer,

Q. M. O. & O. R.

DEAR SIR,

To a communication of Mr. R. Flanagan's, dated 30th December, 1876, wherein he intimates, that owing to delays caused by the Division Engineer, he was prevented getting the foundations of Batiscan Bridge, ready for masonry early in the season; I beg to reply as follows: Three delays are specially referred to, thus:—1st. "Delayed from 4th to 16th of March."—2nd. "Delayed to or until the 3rd of August."—3rd. "Delayed until the 27th of October." My answer to first complaint is: there was no Division Engineer appointed until after the 16th March. To the other two complaints I would reply that work was laid out at the following dates:—19th and 22nd July, 3rd and 22nd August, 22nd September, and the 27th October; and would add that in all cases as soon as possible after it was asked, I either went down myself or sent my assistant. I was frequently at the bridge at other dates besides the above named, and always ready and willing to give information and show the points.

In reference to the extra rows of piles driven, owing to wrong centres, I hold myself in no way responsible. I accompanied Mr. Odell, the Contractor's Engineer, to Batiscan, on the 16th March, 1876, to assist him in laying out piers Nos. 1 and 2 west. As the great depth of water prevented the other piers being found, I assisted him to chain from a hub (at some distance) which was assumed to be correct, and the work was laid out accordingly.

In regard to the extra 10 feet of excavation for west abutment, I gave no orders to make it so wide, the face only was staked out, and as Mr. Flanagan had access to the plan of the platform, he should only have excavated the size to suit. I think however the extra size was an improvement, as it gave more room to work in.

Hoping the foregoing statements and explanations are clear and satisfactory,

I remain,

Your obedient Servant,

L. B. HAMLIN.

APPENDIX No. 43.

STEEL RAILS, CORRESPONDENCE AND
SPECIFICATIONS.

Quebec, 12th May, 1876.

HON. H. G. MALHIOT,
Chief Commissioner.

SIR,

Referring to Mr. C. P. Sandberg's letter to the Hon. Geo. Irvine, to which you have called my attention, Mr. Sandberg recommends certain modifications of the plan and specification of rail and fish joints sent him on the 6th of April. He recommends keeping his own section, which can be reduced in rolling to fifty-six pounds. Mr. Sandberg thinks it is difficult to roll my section, owing to thinness of the flange. Many of the American *modern* sections have similarly thin flanges as that proposed by me, but as an equally good rail will be had by the reduction proposed I do not object to it.

Mr. Sandberg further [recommends keeping his original fish plate with my enlarged bolt. This I also consent to. The alteration was made at the especial request of Mr. McGreevy to save duty chargeable on the *fluted* pattern.

Mr. Sandberg thinks my specification and tests so stiff that they will involve from 10s. to £1 extra per ton. I can only say that these tests are used by two of the best English Engineers, Messrs. Rendel and Brunless, and are likewise in vogue with the best American firms.

The bolt test of bending cold is a usual one in this country.

The immersion of the steel fish plates in oil, which Mr. Sandberg has not used, increases their strength from 30 to 50 per cent.

I recommend that both the latter conditions be retained, but as Mr. Sandberg states "that his working specification has stood good for say 100,000 tons Canadian rails inspected by him, which is a practical basis in a strict inspector's hands, sufficient to insure satisfaction without unnecessary cost," I am prepared to adopt it mainly from Mr. Sandberg having the name of being a careful, honest and strict inspector. I only desire to have the best *uniform* pattern in use, and this made of steel that will stand this climate, and usual wear and tear.

I therefore recommend that one uniform pattern and specification for the main lines be maintained throughout, and no job lots that have not been properly inspected during manufacture be admitted.

I remain, Sir,

Your obedient Servant,

A. L. LIGHT.

Quebec, 22nd May, 1876.

C. P. SANDBERGH, Esq., C. E.,

DEAR SIR,

I have yours of the 20th, 21st and 25th ulto., also the 11th inst., together with certain printed documents, for which I am obliged.

By this time you will have received from the Commissioners, confirmation of your appointment made, the 6th of April, also, approving of your specification and form of rail with my remarks thereon.

This matter being settled, you are at liberty to proceed in accordance therewith, independent of the following remarks.

I am surprised that it should have been necessary to adopt the unusual course of recommending changes in my specification so long as that specification made a better rail: fish plate and bolt fastening. If so the ground of probable

additional expense of from 10s. to £1 extra, mentioned by you, need not have much weight, the contractor's schedule price being largely in excess of the present cost of steel rails.

Much of the data from which my specification was prepared, was furnished me by Mr. James Brunlees, of No 5, Victoria street, Westminster, (an eminent, careful and experienced engineer), as that which he uses in his own practice.

The specification is also in accord with the general usage of the best steel manufacturers of America, who adopt thinner flanges than were formerly considered safe, hammer their blooms, drill instead of punch the bolt holes, and condemn concave fish-plates as receptacles for sand tending to wear them rapidly away. Their tests require that steel for the main line shall be capable of being bent double cold. Most of this you will see in the remarks of that eminent authority, on steel rails, Mr. Ashbel Welch, in a paper read in 1875 before the American Institution of Civil Engineers. Referring to the thin modern flanges now in use in America, Mr. Welch says by good authority they ought to break, but eight years' experience under the heaviest traffic in this country *proves that they do not*.

The real question apart from that of mere expense, which where human life is at stake, should not be too closely considered. Does hammering the blooms and drilling instead of punching the bolt holes, as practised in the United States (where labor is high), really make a *safer rail*, in this extremely cold climate. The latter you frankly admit though stating it is more expensive—the former you think can be more cheaply attained by rough rolling.

A diversity of opinion among men so experienced as yourself and the eminent authorities above named, leads to the conclusion that engineers like doctors, often honestly differ upon the best means of obtaining similar results.

I remain,

Dear Sir,

Truly yours,

A. L. LIGHT.

PUBLIC WORKS OF QUEBEC,

Q. M. O. & O. RAILWAY.

MR. LIGHT'S SPECIFICATION—BESSEMER STEEL
RAILS AND FISH PLATES.

GENERAL DESCRIPTION, &c.

1. The rails are to be fifty-six pounds per yard or eighty-eight tons per mile of railway.

2. The rails to be fish-jointed, with Bessemer steel fish-plates, and iron bolts and nuts.

3. The form of rail to be Sandberg's standard section; the fish-joint also to be Sandberg's standard, with such modifications as may be authorized and directed.

4. The steel fish-plates to be formed reversible with four holes punched for bolts with square shaped necks.

5. Each rail to be notched $\frac{3}{4}$ inch and $\frac{3}{4}$ inch at the four corners, and two holes *drilled* near each end.

6. The maker's name and year of manufacture must be distinctly marked on each rail.

7. Inspectors will be appointed to overlook the manufacture of the rails, and to test their quality, and the makers will be required to make all such tests as the inspector may deem necessary, to secure the best description of steel rails manufactured.

DETAILED SPECIFICATION.

Bessemer Steel.

8. The rails to be manufactured from Bessemer steel, and such mixtures of metal must be used in the convertor as will ensure the very best quality of this class of steel, fitted to withstand a climate in which the mercury falls 40 deg. Fahrenheit below zero.

Mode of Manufacture.

9. The rails to be made from an ingot of suitable dimensions which shall afterwards be formed under a hammer, of not less than ten tons, into a bloom, reduced to at least three-fourths its original dimensions; it shall then be reheated and rolled into the finished rail.

Engineer may alter.

10. The engineer or the inspector he may appoint is to have the power of altering or controlling the method of manufacture during the progress of the work in any way he may consider expedient.

General Description as to Finish.

11. The quality of the finished rails as regards toughness combined with hardness and strength is to be such as shall be satisfactory to the engineer; they must be of uniform section throughout and perfectly true to template; they must be straight and sound, free from splits, cracks and flaws, scoria, imperfect welds or defects of any kind, and the ends shall be cut accurately true and square; any rail that becomes warped in cooling, shall be straightened by pressure and not by hammering.

12. To ensure perfect accuracy, the fish plates and bolts will be made at the same manufactory as the rails.

Finishing Fish Plates.

13. The template for the fishing plates must be approved by the engineer, and they must be made exactly thereto. They are to be made from the toughest description of annealed steel, such as shall be satisfactory to the engineer; they are to be sawn off square and punched whilst hot, and are to be without burrs or deformities at the ends; they are to be perfectly straight and smooth on every surface, free from twist and of a uniform section throughout.

Bolts.

14. The bolts will be made of the toughest description of No. 2 iron.

Proportion of Fish Plates, Bolts and Nuts.

15. In the delivery of rails, the proper proportion of fish plates, bolts and nuts must be made with each shipment, or previously. The fish plates, bolts, &c., must be done up in such a manner as will preserve them from loss in transportation.

Holes in Rails and Fish Plates.

16. Each rail is to be drilled at each end with two holes, and each fishing plate is to be punched with four holes; the sizes and positions of all these holes must be exactly in accordance with dimensions given, clean and true, square through, free from burrs on all sides, and perfectly accurate in size and position; any variation from the correct position or from the correct sizes of the holes will render the rails or fishing plates liable to rejection. After the holes are punched, each fish plate is to be heated to a cherry red, and while hot is to be immersed in boiled linseed oil.

Marking.

17. Each rail and fishing plate is to be marked distinctly in some suitable place and in suitable permanent characters as the engineer shall direct with the maker's name or initials, the year of manufacture and the initial letters of the railway.

Lengths.

18. Eighty-five per cent of the rails must be exactly 28 feet long.

19. For convenience of passing around curves, five per cent of the quantity must be twenty-seven feet nine (27.9) long and painted red on the ends, to be easily distinguishable.

20. The balance or 10 per cent, for the convenience of the contractor, may be cut in even lengths of 20, 22, 24 and 26 feet. No variation of these lengths exceeding $\frac{1}{4}$ of an inch will be allowed. Should any of the rails require altering after they have cooled, the operation must be performed cold, as no reheating of a rail at a smith's hearth or in any

other way will be permitted. The weight of the rail is to be 56 pounds per yard, and no rail weighing more than two per cent under the specified weight will be received, and no excess paid for.

21. The rails and fishing plates will be subject to the following tests, or will be tested in any other way the engineer may approve :

Test No. 1.

22. A piece of rail about 12 feet long shall be placed on bearings 9 feet apart, and deflected by means of a dead weight gradually applied to three tons, and after the removal of the weight, which must remain on at least ten minutes, the rail shall resume its original form without indicating any permanent set.

Test No. 2.

23. A piece of rail of convenient length shall be bent cold round a bar or block, having a radius of 6 or 7 inches to an angle of 90 degrees without indicating any fracture.

Test No. 3.

24. A similar piece of rail shall also be placed on centres 4 feet apart, and bent to the same extent by a falling weight without exhibiting any fracture.

Test No. 4.

25. The bolts must be capable of being bent over cold (in the form of a V), without shewing signs of fracture.

26. One per cent at least of the rails must be thus tested.

27. The requisite machinery, tackle and labour for making the above tests must be provided by the contractor.

Power to Reject.

28. The engineer or his appointed inspector shall have power to reject any rails or part of the manufacture which does not comply with this specification; he will also see that all rejected rails are stamped with a distinct mark in two or three places on the underside of the rail.

Engineer's Certificate.

No portion of the rails will be considered as accepted until the engineer has given his written certificate.

Approved,

A. L. LIGHT,
Govt. Engineer.

Quebec, 17th March, 1876.

MR. SANDBERG'S SPECIFICATION FOR STEEL RAILS.

Section.

The rails are to be of the section shown on annexed drawing, $4\frac{1}{2}$ inches high, and $3\frac{3}{4}$ (see drawing) inches on the base, and to be made according to a template, which will be furnished with the order.

The rails are to be perfectly straight and true, and of uniform section throughout their whole length.

Weight.

The rails are to weigh 56 pounds per yard. The usual allowance of 2 per cent on single rail, and 1 per cent on total quantity will be accorded without rejection, but the rails must not be invoiced at more than 56 pounds per yard for the total order, and makers will be answerable for the full weight as per invoice.

Length.

The length of the rails is fixed to 28 feet for at least 85 per cent, with an allowance of $\frac{1}{4}$ inch above or below this measure. Five per cent of the total quantity may be 27' 9" long for curves, painted red at the ends, and the remaining 10 per cent of shorter rails 26', 24', 22', and 20' only.

Punching and Notching.

PUNCHING OF RAILS.—Two circular holes at each end 1" diam. Centre of first hole $2\frac{1}{4}$ " from end of rail. Centre of second hole 5" from centre of first hole.

NOTCHING OF RAILS.—One right hand corner notch at each end $\frac{3}{4}$ " long x $\frac{3}{8}$ " deep.

PUNCHING OF FISH PLATES.—Four square shaped holes $1\frac{3}{8}$ " long x 1" high. Fish plate 20" long. From end of fish plate to commencement of first hole $1\frac{1}{8}$ ". Between first and second holes $3\frac{1}{8}$ ", and between middle holes 4".

Marking.

Each rail must bear the name of the maker and the year in which it is rolled. The letters must be distinct so as to identify the rails. Each rail when inspected and approved must be stamped with the private stamp of the inspecting engineer. The rails will not be accepted unless this has been complied with.

Mode of Manufacture.

The steel must be cast into ingots by the Bessemer or Siemen's process, and must be of uniform quality and equal hardness throughout, and the inspecting engineer will be at liberty to test sample ingots by forging, tempering, bending, or otherwise, to satisfy himself of the proper material being used.

These ingots must be heated well through, then hammered or rolled into a rail of exact section. Flaws or cracks in the ingot must be cut out hot before the last rolling, so as to make a perfectly smooth and clean rail free from cracks, flaws and other imperfections. No patching or mending the flanges will be tolerated.

Inspection.

The rails will be passed in lots not exceeding 1,000 bars each. The engineer or inspector appointed by the buyer will select from each lot a certain number of rails, not exceeding one per cent of the whole, and will test them as follows:—

Tests.

FIRST.—Each of the selected rails must carry 13 tons in the centre, between 3 feet bearings, for five minutes, without permanent set.

SECOND.—The rails must carry in the same position a load of 26 tons without breaking, after this the flange of the rail will be cut and the rail broken. The fracture must show perfect welding, especially in the head.

THIRD.—Each half of the broken rail again placed on 3 feet bearings must stand a blow from a ball weighing 1 ton falling from a height of 15 feet on the rail between the supports without showing any fracture. The bearings are to be of cast iron fixed on oak frames and supported on solid masonry 4 feet deep.

Should one of the rails fail under any of the above tests, the lot will be divided into ten equal portions, and one rail from each will be tested. Each rail then proving unequal to the test, will cause the lot from which it was taken to be rejected.

The inspector of the company is to have the right of entrance to the works at all times, to inspect the manufacture and quality of the materials, and to superintend the testing of the rails; but this inspection is in no way to remove the responsibility of the manufacturer, who is bound to deliver nothing but good sound rails of best workmanship and good materials. Any remarks which the inspector may have to make, are to be addressed to the manager of the works, and not to the workmen therein employed. All rails inspected, approved, and stamped by the inspecting engineer, cannot afterwards be rejected.

Notice of Rolling.

The makers to give eight days' notice to the inspecting engineer of commencing the rolling, and not less than two days' notice of resuming the work after its temporary suspension.

Fish Plates.

To template approved, each fish plate, after it is punched, is to be heated, and while hot, immersed in boiled linseed oil. Fish Plates to be inspected, tested, and approved.

Bolts.

Bolts to be made of best and toughest iron No. 2, Whitworths' thread, and inspected and approved bolts to be packed in strong cases.

APPENDIX No. 44.

DIVISION ENGINEER'S OFFICE,

Three Rivers, 30th Nov., 1876.

A. L. LIGHT,

Chief Engineer.

DEAR SIR,

The inspector informs me that the Contractor's Agent refuses to carry out my instructions in reference to the extra width of East abutment, Champlain Bridge; also, to take the foundation down to the depth ordered. I have instructed both points to be insisted upon, and I shall inform you when I get further particulars, in any case the weather is quite unfit for masonry. Odell has just called and informs me has ordered all building to be stopped. This I suppose will prevent any more difficulties for the present.

Do you wish me to return an estimate of all old material delivered in 1874 and 1875. I have had it all measured.

I remain,

Yours truly,

L. B. HAMLIN.

APPENDIX No. 45.

Three Rivers, P.Q., 26th Dec., 1876.

ALEXANDER L. LIGHT, Esq.,

Chief Engineer Government Railways, Quebec.

SIR,

We have the honor to submit the following report on the subject of the bridge over the Champlain River and St. Malo road. The original plan shews the western abutment 8', 3'' thick, and the eastern 6', 6'' thick. The depth of the foundations, and consequently the height of the abutment, was undefined, and left to the discretion of the Division Engineer.

In consequence of the treacherous nature of the soil, composing the banks of the stream, it was considered necessary, to carry the foundations down, to the level of the bed of the river. This makes the height of the abutments 26 feet. In the event of the portion of the bank, in front of the abutment slipping off, (a contingency very likely to occur), it would have to act as a retaining wall, resisting the pressure of a bank of wet clay and sand. The formula gives 8', 9'' as the requisite thickness of a retaining wall 26 feet high.

These matters having been submitted, the following telegram was received from the Chief Engineer, on the 23rd of November:—"Make East abutment, Champlain, 8 feet 8 inches, same as western," and on the 24th the order was transmitted by telegraph to the inspector Mr. Ross.

In direct defiance of this order the abutment has been built 6', 6'' thick, instead of 8', 3'' and in spite of the protests of the inspector and the orders of the Division Engineer, the foundation has been stopped at a depth of 6', 4'' less than that required, and at a level of about 3 feet above the average low water—the highest level at which the abutment could with safety be founded.

The western abutment has been founded at the depth ordered, and built 8 feet 3 inches thick, and the work well done.

The eastern abutment is now built to a height of 7 feet 6 inches, and the western to a height of 8 feet.

St. Malo Road. In order to save a small expenditure for a temporary bridge, the contractor has been attempting, though with little success, to complete the abutments during weather, which, in our opinion, was unfit for the laying of masonry in cement. It appears to us that after the stone becomes full of frost, the use of hot water and hot sand in mixing the cement, are utterly futile expedients, as the cement must freeze, as soon as it comes in contact with the cold stone. That little time is gained by these operations is proved by the fact that at St. Malo road, they have not succeeded in laying one complete course in more than a fortnight. At Maskinonge, the sub-contractor after a very fair trial, abandoned the attempt to build in this way, of his own accord.

Taking all things into consideration, we are of opinion that the work is not forwarded sufficiently to compensate for the risk of getting bad masonry, and that a peremptory order should be issued forbidding all building in cement until the spring.

We have the honor to be,

Sir,

Your obedient Servants,

L. B. HAMLIN,

JOHN ED. BOYD,

APPENDIX No. 46.

*Division Engineer's Office,**Three Rivers, 19th April, 1877.*

A. L. LIGHT, Esq.,

Chief Engineer.

DEAR SIR,

I deem it my duty to report that the West abutment of the Pepin River Bridge has been seriously damaged by the freshet. The foundation of the South end of the masonry has been undermined by the current, and has fallen partially over. The scour has been entirely caused by gross negligence in not having the abutment secured with rip-rap and the channel properly opened last fall. I strongly urged this to be done, and instructed the inspector to see the order executed, but the contractor's agent would not attend to it—if he had, the accident would not have occurred. * * * *

I advocated piling these foundations, but only platforms were put in. If this accident should have the beneficial effect of preventing the engineer's orders in reference to foundations being constantly disputed, it may be looked upon as a fortunate and not an unfortunate circumstance.

* * * *

Grading and tracklaying is going on at Point-du-Lac. The contractor has commenced to deposit ballast on sections 74 and 75 from sand cuts on section 75; it is too fine.

As there is nothing else important to report,

I remain,

Yours truly,

L. B. HAMLIN.

APPENDIX No. 47.

*Q., M., O. & O. Ry.,
Engineer's Office, Eastern Division,
Quebec, 24th April, 1877.*

HON. THOS. MCGREEVY,

SIR,

Mr. Hamlin reports that the West abutment of the Pepin bridge has been washed away. He states "that this occurred through gross negligence in not having the abutments secured. He further says, that he ordered piles here, but only platforms were put in. If this accident should have the beneficial effect of preventing the engineer's orders in reference to foundations being constantly disputed, it may be looked upon as a fortunate, and not an unfortunate circumstance."

Advantage was taken of the forced absence of Mr. Boyd, the inspecting engineer, last autumn, to put in this work contrary to orders. The same thing was done at the Champlain bridge.

Such unwarrantable interference on the part of your agent is in direct violation of your contract, which very properly defines, "that the orders of the engineer must be complied with in every respect and under all circumstances." I therefore inform you that in future I require that all bridge plans, before they receive my approval, shall shew, by proper borings, &c., the nature of the material on which such bridges are to be founded, as well as the description and depth of the proposed foundation. This will stop your agent from disputing the orders of the Division Engineer, and prevent a repetition of the above disasters.

I remain,

Sir,

Your obedt. Servt.,

A. L. LIGHT.

APPENDIX No. 48.

A. L. LIGHT, Esq.,

Chief Engineer.

DEAR SIR,

I have to report that the contractors are distributing material from the sand cutting west of Pont Rouge, on the side of track, both east and westward, with the intention doubtless of using it for ballast, for which purpose it is entirely unsuitable, being composed of much loam and fine sand. I have spoken to Mr. R. H. McGreevy, and remonstrated with the sub-contractors, as also have the track-master and assistant-engineer by my orders. I also mentioned that while awaiting the construction of a roadway into the Lorette Ballast Pit, they have a large quantity of work to occupy them for some time, in widening the narrow, and raising the low embankments, which can be done from any of the cuttings, which have to be widened and ditched.

I spoke to Mr. R. H. McGreevy on this subject, and he informed me it should be attended to, in fact shewed me a letter which he had written to Messrs. McCarron and Cameron, sub-contractors for ballasting, instructing them to do as I had suggested, but so far no steps have been taken to carry this out.

The sand cutting being the easiest material to move is probably the reason it is most used. Yet as the other cuttings have to be sloped and widened in any case, they should be used where required, instead of being wasted hereafter.

Any material unfit for ballast and distributed for that purpose, I do not purpose to return in the estimate, unless taken from authorized ballast pits. No work has been begun yet to make a roadway into the Ballast Pit at Lorette.

I have just received a fair specimen of ballast from the track-master, which comes from a hill about 1000 feet south of the railway line, at station 1690, about $1\frac{1}{2}$ miles east of River Portneuf—with this and the Lorette Pit, the whole line to the St. Anne's River can be easily ballasted with good gravel.

Yours truly,

(Signed,)

JOHN LINDSAY.

Erratum at close of Appendices, Page 87.

The above Statements are compiled from the Division Engineer's returns, and do not include St. Maurice Bridge = 1,500 c. yards.

The above should be:—"The above Statements are compiled from the Division Engineer's returns, and include the St. Maurice Bridge=4,500 c. yards."

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